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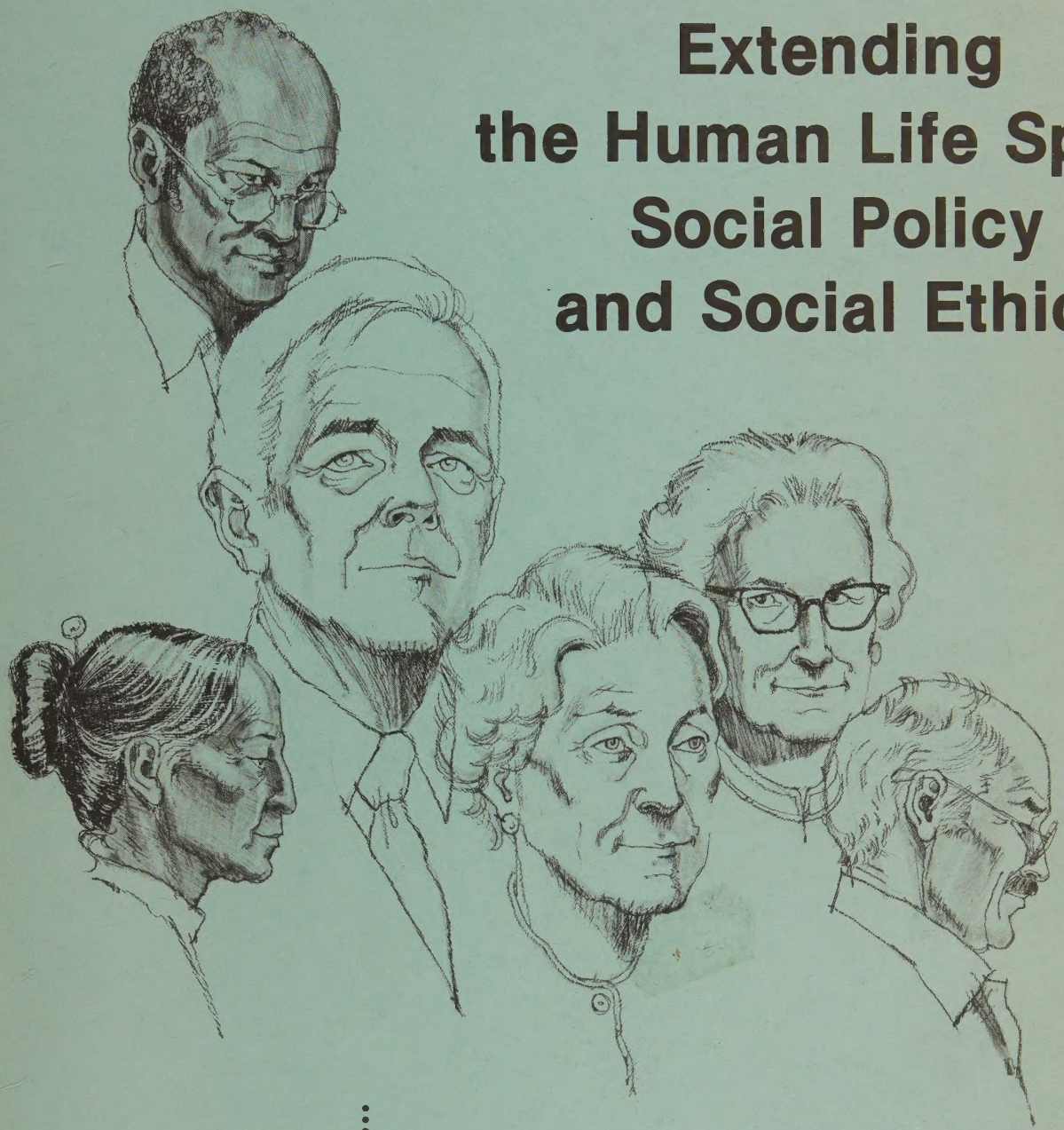
Extending the Human Life Span: Social Policy and Social Ethics



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Extending the Human Life Span: Social Policy and Social Ethics

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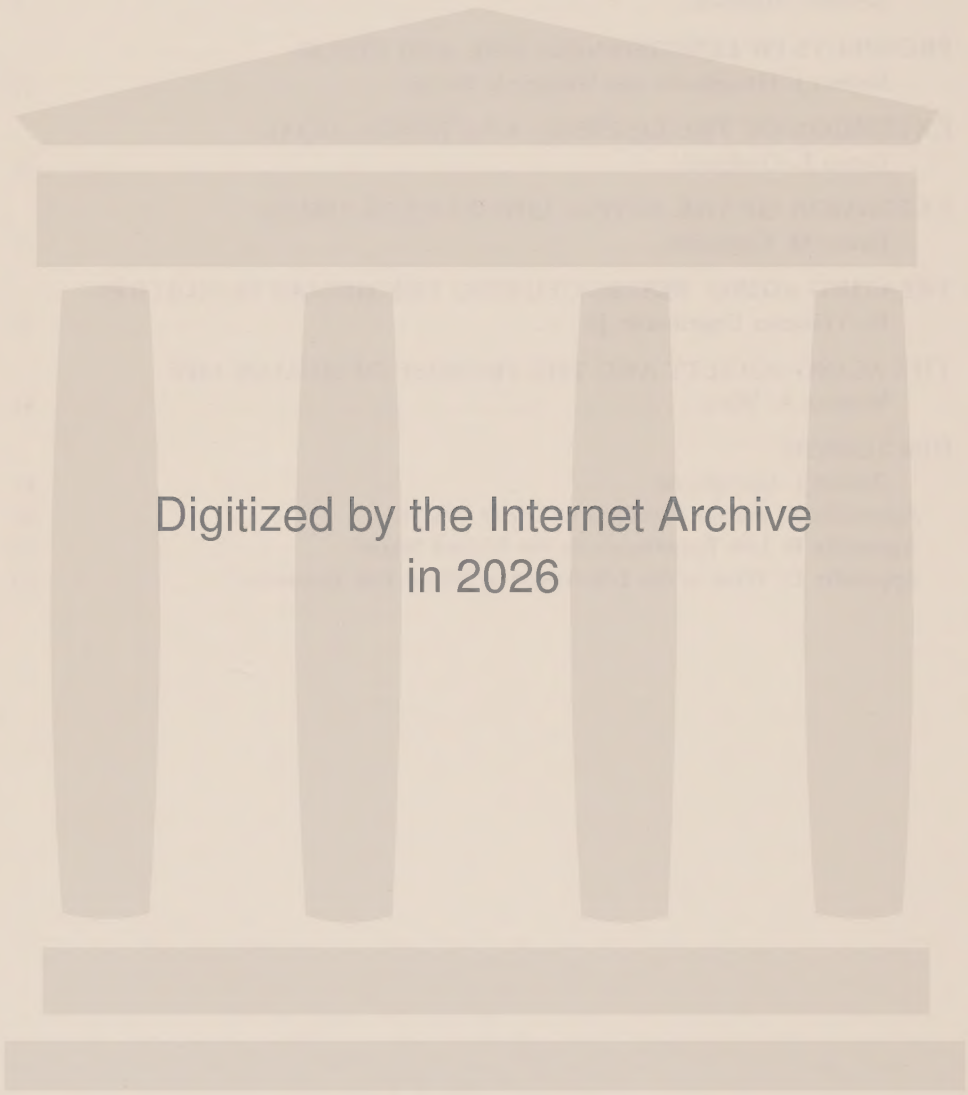
Committee on Human Development · University of Chicago

B 1815

Table of Contents

	Page
PREFACE	III
CONFERENCE PARTICIPANTS	V
PERSPECTIVES ON HUMAN LONGEVITY Leonard Hayflick	1
PROSPECTS OF LENGTHENING LIFE AND VIGOR Robert J. Havighurst and George A. Sacher	13
EXTENSION OF THE LIFESPAN: A NATIONAL GOAL? James L. Goddard	19
EXTENSION OF THE ACTIVE LIFE: ETHICAL ISSUES James M. Gustafson	27
TREATING AGING: RESTRUCTURING THE HUMAN CONDITION H. Tristram Engelhardt, Jr.	33
THE AGING SOCIETY AND THE PROMISE OF HUMAN LIFE Warner A. Wick	41
DISCUSSION Robert J. Havighurst	47
Appendix A: Future Numbers of Older People	59
Appendix B: Life Expectancy in the United States	63
Appendix C: What is the Likelihood of Major Life Extension?	65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preface

A group of faculty members at the University of Chicago undertook in 1973 a 3-year project on the future of aging and the aging society. With support from the National Science Foundation (NSF Grant G1-39091), the project centered around an interdisciplinary seminar of faculty and graduate students who attempted to assess the state of knowledge concerning aging and the aged, and to identify the areas in which new research is particularly needed if public policies are to be well informed over the next decade.

Out of this project a special interest developed in the ethical aspects of policy decisions. Members of the seminar drew up a plan for a conference that would bring together social and biological scientists, policymakers, and social ethicists for an exchange of views regarding the policy decisions that lie ahead. So far as was known, this would be a first attempt to establish a dialogue between persons from such very different backgrounds.

The conference focused upon three topics: the economic welfare of older persons, health services for older persons, and extension of the human life span. Background papers were invited from present or former Federal Government officials, scientists, and ethicists.

A few months prior to the conference, the persons preparing papers came together for a preliminary exchange of ideas. The papers were then completed and circulated among the authors, and copies were sent also to a small list of people who were invited to participate as commentators. The latter were academicians or persons who occupy major positions in private or public agencies. (The full list of participants is shown at the opening of this volume.)

Because the participants had read the papers beforehand, the conference itself consisted of discussion sessions, arranged to promote informal exchange. The discussions proceeded in the presence of a limited number of observers who were also invitees—graduate students, faculty members, local State and Federal Government officials, and representatives of private foundations, all of them persons with special interests or special responsibilities for programs in the field of aging.

The papers relating to the first two topics of the conference—the economic welfare of older persons, and health services for older persons—along with selected portions of the conference discussions, have been published under the title, SOCIAL POLICY, SOCIAL ETHICS, AND THE AGING SOCIETY (Washington, D.C., U.S. Government Printing Office, 1976, Stock Number 038-000-00299-6). The papers and the accompanying discussion relating to the third topic of the conference, extension of the human lifespan, are presented in this volume, along with brief appendix materials prepared by the editors.

In preparing the present papers, authors were asked to leave aside those issues, important as they are, that have to do with prolonging the life of the individual patient in the terminal stage of illness, the issues that have come to be known as "the right to die" or "death with dignity." They were asked to focus, instead, upon the more general question of basic biological research that might lead to extending the longevity of the human species.

In this connection, it was pointed out that two general strategies for lengthening the lifespan are now being pursued by biomedical and biological scientists. The first is

the continuing effort to conquer disease. The second is the attempt to identify the intrinsic biological processes that are thought to underlie aging and that proceed independently from disease processes—that is, to discover the genetic and biochemical secrets of aging, then to alter the biological clock that is presumably programed into the human species. The second approach is directed at rate control, rather than disease control. The authors were asked, What should be the primary objective of the science of biogerontology—to improve the quality of life for older people, or to extend the lifespan of the human species? Can the latter be achieved without cost to the former? If the human lifespan could be extended beyond the present maximum of 110 or 115 years, what would be the major deleterious and the major beneficial effects upon the society? Is it likely than an increased lifespan can be achieved that will lengthen the period of healthy, active life; or instead, would it mean a lengthened period of deterioration at the end of life? If the numbers of very old people increase, must the numbers also increase of those who are physically or psychologically impaired? Can those risks be weighed against the benefits? How are social and ethical values to be weighed against economic values? Can a new priority of social values be effected?

Other questions included, How much of our scientific resources should be allocated to research addressed directly to the extension of the human lifespan? What would be the social and ethical implications if biologists were to succeed in discovering a "magic elixir" that would extend active life expectancy by 15 to 20 years? Should there be new government controls on the directions of research?

Two of these papers have been written from the perspective of biological researchers, the first by Professor Leonard Hayflick, describing the state of knowledge regarding human longevity and the prospects for a major extension of the lifespan; the second, by Professor Robert J. Havighurst and Mr. George Sacher, describing two different approaches to life extension and the possible social consequences of each. Another paper was prepared by Dr. James Goddard, former Commissioner of the U.S. Food and Drug Administration, setting forth some of the social issues as seen by a government official and some of the problems of government regulation. Three papers were prepared on the ethical issues of life extension, one by Professor H. Tristram Engelhardt, philosopher and physician, one by Professor James Gustafson, theologian and ethicist; and the last by Professor Warner Wick, philosopher-ethicist, indicating how the specific questions regarding life extension relate to the underlying philosophical questions about what constitutes a good life in a good society.

We are indebted to these authors for the thoughful ways in which they have dealt with the questions originally put to them, and for the ways in which they all—whether as scientist, government policymaker, or ethicist—have broadened and deepened the issues before us.

We are indebted also to those who provided the financial support for the conference at which these papers were discussed: to the National Science Foundation, and in particular, to Dr. George Brosseau, then Program Manager, Office of Exploratory Research and Problem Assessment, RANN (NSF); to the Edna McConnell Clark Foundation; and to the Trinity Church of the City of New York.

Bernice L. Neugarten

Robert J. Havighurst

Chicago
1977

conference participants

*Odin W. Anderson, Professor of Sociology and Director, Center for Health Administration Studies, University of Chicago

*Robert M. Ball, Senior Scholar, Institute of Medicine, National Academy of Sciences (formerly Commissioner, U.S. Social Security Administration)

D. J.R. Bruckner, Vice-President for Public Affairs and Director, Center for Policy Study, University of Chicago

*Richard V. Burkhauser, Department of Economics, University of Chicago

*James C. Corman, Representative to the U.S. Congress from the 22nd District of California, House of Representatives, Washington, D.C.

Nelson H. Cruikshank, President, National Council of Senior Citizens, Washington, D.C.

*B. J. Diggs, Professor of Philosophy, University of Illinois at Urbana-Champaign.

Alan Donagan, Professor of Philosophy, University of Chicago

**H. Tristram Engelhardt, Jr., Assistant Professor of the Philosophy of Medicine, University of Texas Medical Branch, Galveston

Richard A. Epstein, Professor of Law, University of Chicago

Jane E. Fullarton, Director, Division of Health Research, Office of Policy Development and Planning, Office of the Assistant Secretary for Health, U.S. Department of Health, Education, and Welfare

**James L. Goddard, formerly Commissioner, U.S. Food and Drug Administration

*Byron Gold, Fellow, Center for Study of Welfare Policy, University of Chicago and Special Assistant to the Commissioner, Administration on Aging

**James M. Gustafson, University Professor of Theological Ethics, University of Chicago

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*George S. Tolley, Professor of Economics, University of Chicago

**Warner A. Wick, Professor of Philosophy, University of Chicago and Editor, ETHICS

Rod Yarling (Conference Coordinator), Department of Social Ethics, University of Chicago

---

*These persons prepared background papers which appear in the first volume of proceedings, *Social policy, social ethics, and the aging society, 1976.* Washington, D.C.: U.S. Government Printing Office, Stock number 038-000-00299-6.

**Papers prepared by these persons are reproduced in this volume.

Perspectives on Human Longevity*

Leonard Hayflick

If the future can be judged by the past, then the impact of biomedical research on human longevity in the next 25 years in this country should be to extend life expectancy considerably beyond the present 70 years. Yet the likelihood of a net increase occurring by the year 2000 of the magnitude seen since 1900 is very doubtful. Life expectancy at birth in 1900 was about 49 years and in 1950 it was about 68 years—a net gain of 19 years. Since 1950, however, the gain has been only 2.4 years.

Why has there been such a profound increase in life expectation in the first half of this century and, in the beginning of the second half, an equally profound leveling off? That this leveling off has occurred is even more impressive if one accepts the common notion that the extent of advances made in biomedical research in the past 25 years has been greater than those made in all previous years. The answer to this apparent dilemma derives from a consideration of the important distinction between life expectancy and lifespan.

It is generally believed that the human lifespan, of about 100 years, has not changed since recorded history, but what has changed is the larger number of people surviving toward this apparent limit (figure 1). Deaths in the early years are becoming increasingly less frequent, resulting in life tables that are simply becoming more rectangular as indicated by the direction of the arrow in figure 2. In many privileged countries, one can now reasonably expect to become old, which is a very new phenomenon, indeed.

*Supported, in part, by Grant HD04004 from the National Institute of Child Health and Human Development, National Institutes of Health, Bethesda, Maryland.

Fig. 1. From L. I. Dublin, A. J. Lotka and M. Spiegelman, Length of Life. The Ronald Press Co., New York, 1949.

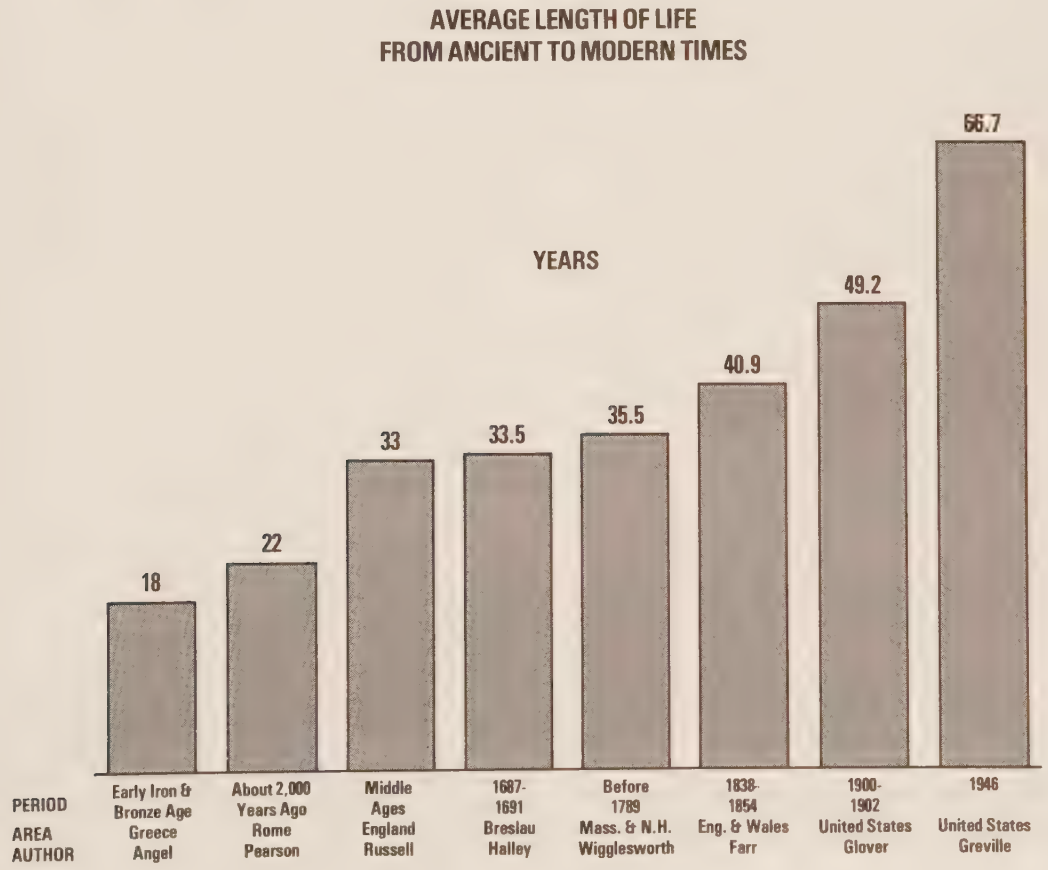
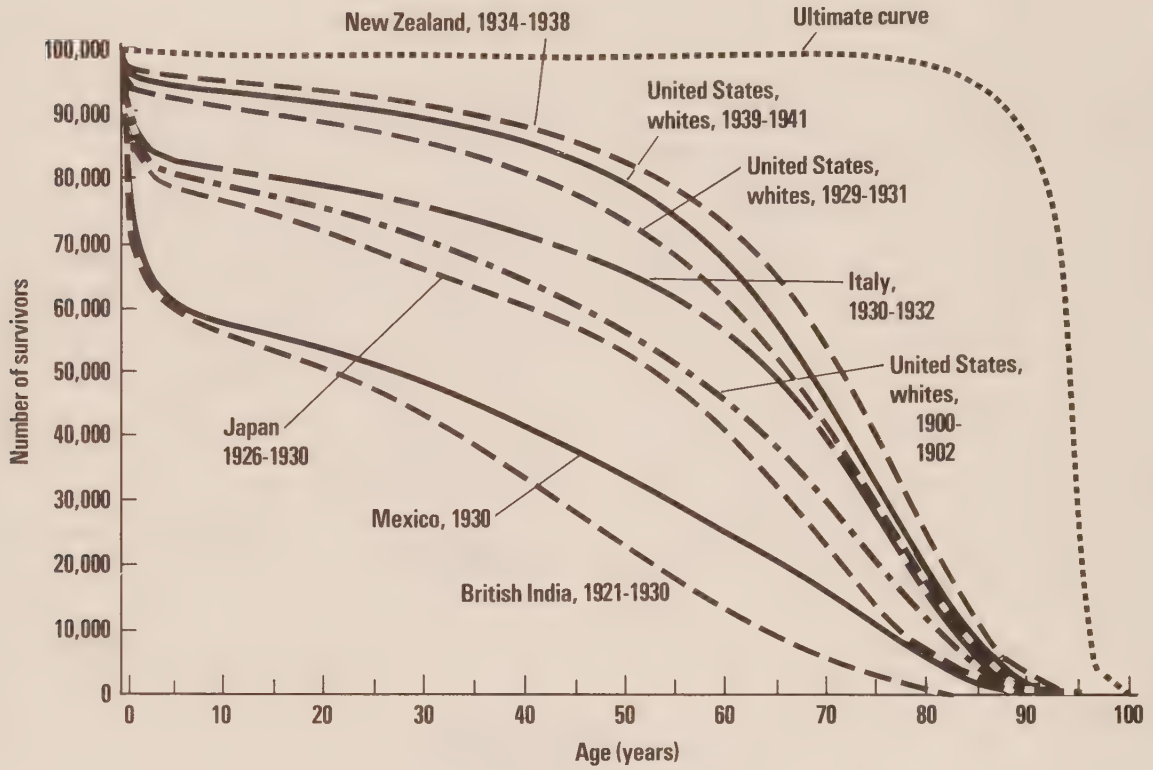


Fig. 2. Adapted from Comfort, A. Aging: The Biology of Senescence, Holt Rinehart & Winston, Inc., New York, 1964.



In a Utopian world where the two leading current causes of death would be resolved, the elimination of cardiovascular diseases and cancer would yield a net increase of about 20 years in life expectation at birth and only slightly less at age 65 (table 1). This figure is almost identical to the net increase in life expectation achieved at birth in this country from 1900 to 1950. If deaths from cardiovascular diseases and cancer were to be eliminated in the next 25 or 50 years, then after that spectacular accomplishment, the leading cause of death would be accidents, which because of their statistical nature are not likely to yield to total elimination. Thus the social, psychological, political, and economic impacts of resolving the two leading causes of death in the next half-century can be reasonably assessed by studying like changes that have occurred in the first half of this century when a similar increase in life expectation occurred.

Let us next consider a world in which *all* causes of death resulting from disease and accidents are totally eliminated (table 1). What would be the effect on human longevity and the human lifespan? The effect would be to realize the ultimate rectangular curve

Table 1

Gain in Expectation of Life at Birth and at Age 65 Due to Elimination of Various Causes of Death

Cause of death	Gain in years in expectation of life if cause was eliminated	
	At birth	At age 65
Major cardiovascular-renal diseases	10.9	10.0
Heart diseases	5.9	4.9
Vascular diseases affecting the central nervous system	1.3	1.2
Malignant neoplasms	2.3	1.2
Accidents excluding those caused by motor vehicles	0.6	0.1
Motor vehicle accidents	0.6	0.1
Influenza and pneumonia	0.5	0.2
Infectious diseases (excluding tuberculosis)	0.2	0.1
Diabetes mellitus	0.2	0.2
Tuberculosis	0.1	0.0

Source: Life tables published by the National Center of Health Statistics, USPHS and U.S. Bureau of the Census, "Some Demographic Aspects of Aging in the United States," February 1973.

(figure 2) in which citizens would live out their lives, free of the fear of premature death, but with the certain fate that on the eve of their 100th birthday, they would drop dead.

Biomedical research has trained its heavy artillery almost exclusively on the disease-associated causes of death. Scant attention has been paid to the underlying causes of biological aging that are not disease-associated but which, in clocklike fashion dictate for each species a specific maximum life span. To be sure, the physiological decrements that occur in advancing years increase vulnerability to disease, but unless more attention is paid to the fundamental nondisease-related biological causes of aging, the fate of all persons will be death on or about their 100th birthday.

Prospects for Increasing Human Longevity

As implied, there are two ways in which the efforts of biomedical research can be expected to extend human longevity in the next 25 years. The first is to reduce or eliminate the major causes of death, in particular, cardiovascular diseases and cancer. The results of ameliorating minor diseases will be minimal. For example, if tuberculosis were completely eliminated, there would be a mere 0.1 year gain in life expectancy at birth (table 1). Thus it could be argued that if an increase in life expectation becomes the main goal of biomedical research, all such research should be directed toward the elimination of the two major causes of death. This position, although less than humane, and not likely to attract many adherents, is nonetheless the most logical conclusion to be derived from life-table studies and the projections dealt with in table 1.

The second way in which biomedical research can deal with human longevity is to address itself specifically to the underlying nondisease-related fundamental biological causes of age changes. These are not diseases but are the basic biological changes that result in those physiological decrements characteristic of aging and upon which are superimposed an increasing vulnerability to disease. The latter, in fact, defines the science of gerontology. Such an approach then does not directly concern itself with efforts to increase human life *expectancy* but rather to extend what appears to be a fixed *lifespan* that differs in its length for man and all other animal species.

As a measure of the current effort put forth toward these two approaches, funds spent on cardiovascular disease and cancer research are one hundred times greater than the funds spent in gerontology. It is also probable that the number of researchers, and consequently the amount of effort, in both these areas also differs by a hundredfold. Consequently, the likelihood that any significant increase in human longevity will occur in the next 25 years depends upon (1) significantly better cure rates for cardiovascular diseases and/or cancer, and/or (2) significant advances in our understanding and ability to manipulate the biological clocks that set for each species a mean maximum lifespan.

If potential success in either of these endeavors can be measured by the current attitudes and priorities of the biomedical research establishment, then it is clear that the search for cardiovascular disease and cancer cures are much more likely to effect human longevity than is gerontological research. The further conclusion is that by curing these two diseases a maximum of 20 years of additional life expectancy could be attained, but with successful efforts to increase the lifespan itself no fixed end point is ruled out. Furthermore the resolution of the two leading killers will in no way reverse or half the decline in physiological decrements characteristics of age changes, whereas efforts to increase the lifespan could lead to such a reversal. Clearly research in cardiovascular diseases and cancer should not be stopped, but if our goal is to maximize opportunities to effectively increase human longevity, then our current priorities are seriously out of balance. If this imbalance continues unchanged the likelihood is very small indeed that the research accomplishments of a handful of underfunded gerontologists will affect the human lifespan.

Some Immediate Possibilities

In spite of this pessimistic view there is, in the judgment of many gerontologists, at least one comparatively innocuous way in which the human lifespan can undoubtedly be extended significantly. The method is based on classic studies made in the 1930's and confirmed in many laboratories for a number of animal species, including the rat in which it was first described.[1,2] The method is to simply reduce the caloric intake to such a level that undernutrition but not malnutrition occurs. This is done by providing an

[1] McCay, C. M., Maynard, L. A., Sperling, G., & Barnes L. L. Retarded growth, lifespan, ultimate body size and age changes in the albino rat after feeding diets restricted in calories. *Journal of Nutrition*, 1939, *18*, 1.

[2] McCay, C. M., Pope, F., & Lunsford, W. Experimental prolongation of the lifespan. *Bulletin of New York Academy of Medicine*, 1956, *32*, 91-101.

animal with a diet sufficient in all necessary nutrients but very low in calories. Longevity can then be increased by as much as 50 percent. The effects are most pronounced if caloric restriction diets are initiated when animals are very young. This results in a stretchingout of the developmental stages such that infancy, puberty, maturity, adulthood, and aging simply occur at later than usual points in time so that the total lifespan is increased.

On the assumption that undernutrition in man would yield similar results, it is of interest to observe that in the 40 years since this has been known, no human has consciously chosen to undertake it, even the biologists who know the data best. Considering the number of nostrums and treatments that have been foisted on a gullible public as antiaging regimens, the lack of interest in underfeeding is, upon superficial consideration, truly remarkable. On the supposition that the method is widely known, that it works, and that it is not dangerous, the main conclusion that can be drawn from the notable lack of interest is that for most people the quality of life is more important than its quantity.

If this is so, then an important lesson can be learned. Any method that might increase human longevity is unacceptable even if it minimally affects the enjoyment of life. It might be amusing to consider the reciprocal question: Will many people opt for a treatment that would accelerate aging and presumably give twice the pleasure (and twice the grief) in half the time?

Another aspect of this question bears on whether any method shown to increase human longevity will, in fact, be used. The notion that any method guaranteed to reduce illness or extend life would not be used may at first seem to be naive, but we are, nonetheless, surrounded by that reality. Consider poliomyelitis and its tragic consequence. Even with the availability of a highly effective prophylaxis in what surely must be considered to be the most painless form of administration (one drop of a sweet-tasting solution on the tongue), fully 40 percent of preschool age children in this country are not immunized. When the vaccine first became available, long lines of people waited for treatment. The current apathy is due largely to the fact that, unlike the older generation, young adults have never seen a polio victim. Consequently, a strong motivation to voluntarily immunize their children is lacking, and were it not for the legal requirement that immunization is necessary for school admission, the likelihood is that immunization against polio would fade to zero in a few years. In order to maintain a proper level of motivation to immunize, the best method probably would be to allow a sufficient number of crippled polio victims to hobble around the streets as constant reminders of the threat. Perhaps it would be more humane to secretly employ paid actors for this purpose.

It would be my guess that like the one example cited of the many that could be given, any regimen designed to increase longevity, even one as simple as a drop of sweet-tasting fluid on the tip of the tongue, would fail one generation after its initial use. Quite obviously if no one ever saw an aged individual the likelihood is nil that he could be persuaded that for lack of treatment he might age.

To Sleep, Perchance To Dream . . .

There remains yet another method for increasing life expectancy that bears consideration. Although it will not result in an extension of life on an absolute time scale it is interesting to consider a form of increased longevity based on the self-evident proposition that life can be lived only when individuals are both physically and mentally active. Since, for most individuals, sleep consumes nearly one-third of our lives, any method that reduces the time spent sleeping should result in an increase in productive occupation and the enjoyment of life—that is, if sleep itself is not considered to be either productive or enjoyable. Sleep researchers tell us that no detectable effect on health has been observed in those individuals who have learned how to make a modest reduction in the length of time usually spent asleep. The impact of this change would be profound, for if we were to reduce by one-half hour the average of 8 hours spent sleeping, the net effect on "life-extension" would be an increase of more than 2 years. This "increase in life expectancy" is equivalent to living in a society where deaths from cancer do not occur at all.

Other Alternatives

The patchwork method of resolving individual diseases, together with other public health prophylactic measures, is of predictably limited value if our goal is to increase human longevity by more than 20 years. The results of such measures, although certainly desirable, will not further increase the length of vigorous life since most cardiovascular diseases and cancers are associated with advancing years. To resolve diseases occurring late in life means that those who are saved merely would continue to suffer those physiological decrements to which the aged are all prone. Taken together, the characteristics of these decrements, their predictable occurrence at specific periods of time in the life of each individual, and the uniform lifespan for all animal

species strongly suggest the presence of a clocklike mechanism that dictates the occurrence of age changes.

What is the likelihood that we will be able to understand the workings of this clock and to tamper with it? In my judgement the likelihood that a full understanding of the mechanism and the capability of tampering with it is unattainable in the next 25 years. The basis for this speculation is simply the observation that the rate of gain in our understanding and ability to intervene in similarly complex biological processes, e.g., biological development, cancer, and genetics, has been so slow that, if extrapolated to gerontological inquiry, it will not yield dramatic results in as short a time as 25 years. Superimposed on this consideration is the observation that by sheer weight of numbers of investigators and dollars available, the likelihood is small that a handful of underfunded but dedicated gerontologists will soon understand the mechanism of aging sufficient to deal with it.

Short of this, however, is the distinct possibility that a complete understanding of the fundamental mechanism of aging is unnecessary in order to permit us to alter the process. Many human illnesses are currently dealt with adequately without a full understanding of the mechanism and, in several cases, even without proof of etiology. Based on this argument it may not be premature even today to initiate studies on the age-decelerating effects of a variety of potentially useful treatments. It has been suggested that one reason for not testing such innocuous means as calorie restriction is that the human lifespan affects not only the investigated but also the investigator. Consequently, it is argued, gerontologists are unwilling to undertake experiments whose outcome may only become known to their children.

Nevertheless, some believe that a battery of short-term tests for rate-of-age-changes that could be measured over a decade or less might adequately substitute for measurements made over a lifetime.[3,4] Models for this approach have, in fact, been developed to assess the possible age accelerating effects of irradiation on Hiroshima survivors. One could simply assess the rate of change in a number of unrelated physiological decrements over a 5- or 10-year period in treated and untreated human subjects, with the expectation that, if most of these variables were affected, the effects could be extrapolated to effect longevity.[3,4] Studies of similar design and magnitude are now underway to test, for example, the effects of diet on heart disease.

An approach such as this has a great deal of appeal, not the least of which is the fact that it is currently feasible, and we know of several possible age-decelerating treatments that would probably be morally and ethically acceptable if a sufficient number of volunteers could be found. In particular, caloric restriction and the effect of antioxidants could be studied immediately. Caloric restriction is inherently safe since it is both voluntarily and involuntarily practiced by many people, and antioxidants, existing as they do as food preservatives, have already gained acceptance by the Food and Drug Administration for human ingestion.

Thus the arguments in favor of this kind of approach, rather than the control of specific diseases, can be summarized as follows:

1. Disease elimination will not retard the processes of aging, but approaches designed to specifically affect the rate of age changes will do so.
2. The approach is currently feasible from the standpoint of several practical considerations including cost, ethics, logistics, and time.
3. It is easier to affect a biological rate than it would be to prevent its occurrence. It should be easier, for example, to postpone the occurrence of cancer or atheroma than to cure these conditions.[3]

Demographic Projections

It is well known that the proportion of individuals in our society over the age of 65 has been steadily increasing. In the last 100 years their proportions of the total population have increased from 3 to 10 percent (figure 3), and the aged have become a larger proportion of the nonworking component of the population which includes the nonworking youth. This nonworking population component is largely supported by the work force itself, and if current population trends continue it will be the elderly who will command increasingly more support.

Within 50 years it is expected that those over 65 will number nearly 40 million (figure 4). This prediction does not take into account any major resolution within 50 years of the two leading causes of death—cardiovascular disease and cancer. If some significant cure rate were to occur, however, we might have as many people over 65 as under 15 in the year 2025.

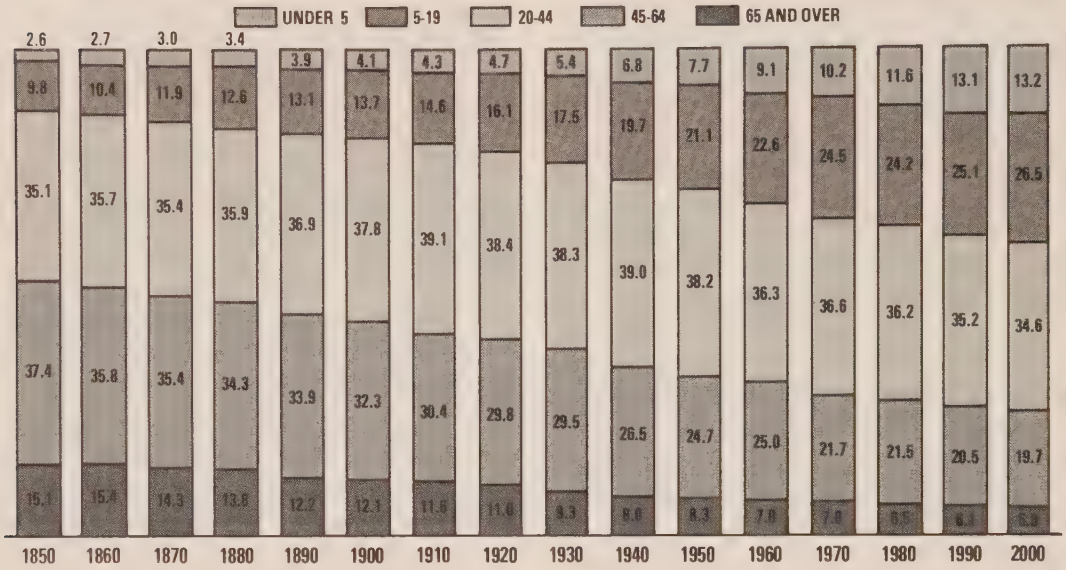
If zero population growth were achieved and maintained, the family size of old people would obviously be

[3] Comfort, A. Measuring the human aging rate. *Mechanisms of Aging and Development*, 1972, *1*, 101-110.

[4] Comfort, A. Test battery to measure aging rate in man. *Lancet*, 1969, II, 1411-1415.

Fig. 3. From L. I. Dublin, A. J. Lotka and M. Spiegelman, Length of Life, The Ronald Press Co., New York, 1949.

PERCENT DISTRIBUTION OF TOTAL POPULATION BY AGE; UNITED STATES 1850 TO 2000*



*1850 to 1940 from United States census enumerations; 1950 to 2000 from estimates by the Bureau of the Census, 1947.

Fig. 4. From U.S. Bureau of the Census, Current Population Reports, Series P-23, No. 43. Some Demographic Aspects of Aging in the United States. U.S. Government Printing Office, Washington, D.C., 1973.

Growth of the Population 65 Years and Over: 1900 to 2020

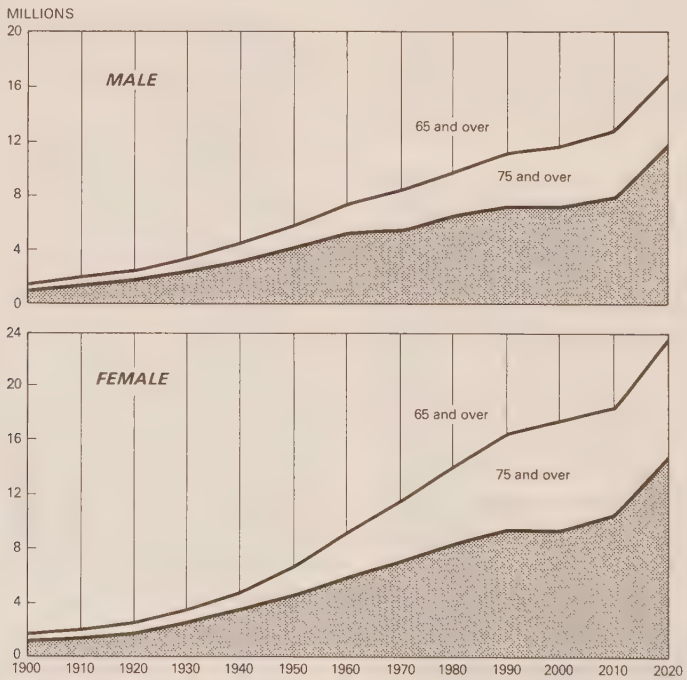


Fig. 4. From U.S. Bureau of the Census, Current Population Reports, Series P-23, No. 43. Some Demographic Aspects of Aging in the United States. U.S. Government Printing Office, Washington, D.C., 1973

reduced and there would occur along with this a diminution in the economic, social, and psychological benefits that now accrue from adult children. The inevitable consequence would be a further acceleration of current trends in which the government would be providing more health care, food, housing, recreation, and income to the elderly. Since it could safely be assumed that the proportion of those in government over 65 would also increase, the closest thing to a gerontocracy could prevail in 2025.

Since zero population growth might be achieved by the year 2025, it is interesting to speculate on the consequences of another extreme condition—that is, a population in which no one dies at all. The immediate effect on the growth rate of the total population would be significant since the growth rate would be increased by the death rate. In the long run, however, the increase would not be dramatic.[5] The increase in growth rate would be somewhat less than one-half million persons per year in a population of 250 million—over and above, that is, the number of births presently being added to the population each year. (In 1974, the number of births was approximately three million. If there were no mortality, the number of births would be an additional one-half million, based on the projection that those females who now die in childhood would survive and would bear children.)

Consequently, even the stupendous achievement of attaining biological immortality would not greatly increase the total population—that is, if those achieving biological immortality did not concomitantly gain in fecundity. However, even a steady-state annual increase of one-half million persons over the present annual increase of three million would make a significant impact after several years.

After the initial large impact of a shift to zero mortality, the rate of increase of the elderly would change slowly. Since with the current life expectancy of 70 years any large reductions in death rates would be limited to persons over 60, the elimination of all deaths would increase the proportion of older people. If the birthdate were to decline to zero—the most unlikely event of all—then quite obviously the population would eventually consist entirely of centenarians and then of supercentenarians.

Aging Russian Style

No discussion of the prospects for increasing human longevity would be complete without considering the claims of superlongevity attributed to three geographically disparate peoples—for if these claims were true, it would be reasonable to conclude that there is, indeed, a factor or factors that lead to increased human longevity and, more importantly, if these factors were known, they could be manipulated to apply equally to other people as well.

One of the three groups is found in the Andean village of Vilcabamba in Ecuador, the second is found in Hunza in the Karakoram Range of the Pakistani region of Kashmir, and the third is found predominantly in the Abkhazia and Osetia regions in the Caucasus of the Georgian Republic of the U.S.S.R.

In order to appreciate the magnitude of the claims made by these groups it is important to realize that in other parts of the world the number of centenarians in the population is normally about two or three per 100,000.[6] Only one person in a million reaches the age of 105, and only one in 40 million will live to be 110. Yet in the three regions mentioned, not only are there claims of higher proportions of centenarians, but many individuals claim ages of 120, 130, and even 150 and 160 years.

In addition to the Georgian Republic, the whole Caucasus area, with a population of 21,290,400 (in 1959), was reported to have 8,890 centenarians (45 per 100,000) and about 500 people claiming to be between 120 and 170 years of age. In certain areas of Azerbaijan claims of 300-400 centenarians per 100,000 have been made! In the census of 1971 the village of Vilcabamba in Ecuador, which had a population of 819, claimed nine centenarians with one individual purportedly 123 years of age. This extrapolates to an incredible rate of 1,100 centenarians per 100,000 people.

Unhappily, however, none of these claims, which have enjoyed widespread popularity in the news media, can be authenticated.

In Hunza, very few statistical data are available and the Hunzukuts, who have no written language, cannot even point to falsified birth records. The Vilcabambans are very isolated and their birth records are either nonexistent or totally unreliable. One gerontologist who recently returned from his second trip to this village after a lapse of 5 years was told by several supercentenarians

[5] U.S. Bureau of the Census, *Current Population Reports, 1973, Series P-23, No. 43. Some Demographic Aspects of Aging in the United States.* Washington, D.C.: U.S. Government Printing Office.

[6] Ed's. note: The 1960 Census for the USA gave 10,369 aged 100 or over compared with 4,475 in 1950. The 1970 Census gave an obviously much too large number, caused by a widespread misinterpretation of the Census taker's question. Therefore, we may estimate the probable number aged 100 or over in 1970 as an increase over 1960 in the same ratio as the age group 95-99 increased between 1960-70. This gives us an estimate of 20,000 people aged 100 or over in 1970.

that during his absence their ages had increased by 7 to 10 years!

In the three areas of Hunza, Vilcabamba, and Soviet Georgia, it was long suspected that some common geographical, climatological, dietary, genetic, or lifestyle situation could account for the claims, yet no common denominator has been found. More important, however, is that the claims of superlongevity themselves cannot be substantiated in any of these regions. The best studied situation is that found in the U.S.S.R. where the evidence is a curious admixture of social mores, pseudoscience, and politics, sadly reminiscent of the Lysenko Affair.

First and foremost is the complete lack of valid documentation for these claims since all census information is based on verbal replies unsubstantiated by documentation. Curiously, census data in the U.S.S.R. reveal that the number of centenarians outside of the Caucasus area dropped from 1926 to 1970 but increased within this area. Dr. Zhores Medvedev, the Russian gerontologist, now a London resident, speculates that this imbalance is most probably connected with an improvement in the cultural and educational levels outside of the Caucasus and where, therefore, the likelihood of collecting spurious information is reduced.[7] (Medvedev draws an analogy with similar claims for large numbers of centenarians among black Americans, and he suggests that the claims are attributable to the same cause.)

As for birth records, internal identity cards only came into use in the U.S.S.R. in 1932 for urban areas only, and dates of birth were recorded only from oral information. Furthermore, in the Moslem areas of the Caucasus where the centenarian claims are most exaggerated, there is no birth registration at all. It has been suggested that the Moslem year, which spans a 10-month period, caused some misunderstandings when census takers arrived. In Christian areas birth records were kept prior to 1917 in special church registers, but because 90 percent of all churches were destroyed between 1922 and 1940, these records are almost completely lost. Not one of 500 supercentenarians questioned in the Caucasus could produce a valid document in support of his claim.

General census statistics in the U.S.S.R. clearly show that females 90 to 99 years of age exist in a ratio of 3:1 to males, yet in the group of Georgian centenarians the ratio after the age of 100 clearly favors the males. Is it more likely for centenarian men to exaggerate their age than women? A further curiosity is that tendencies to exaggerate age in most industrialized countries occur more frequently in the very young and very old age groups. Persons in their middle years are more apt to reduce their real ages.

Medvedev, in further investigations on the superlongevous people of the Georgian Republic, offers some interesting notions on why these claims persist. Very old people in these regions enjoy the highest levels of social authority and the older a person is, the more respect and honor he receives. "The most elderly people are almost regarded as saints." These traditions create a stimulus for age exaggeration, especially when documentation does not exist and when no living witnesses can contradict the claims. Furthermore, the national and international publicity surrounding the superlongevous, such as images on postage stamps, frequent news media photographs and stories, and establishment of centenarian bands, chorale and dance groups, have made these areas profitable tourist attractions. The Novosti Press Agency itself derives income from the sale of stories and photographs of the supercentenarians to the gullible Western news media.

The villages compete to have the oldest resident in the U.S.S.R.; the competition is fueled by this circus atmosphere; and longevity records are pushed upwards annually. Associated with these claims, and providing further impetus to the exaggerations, is the political propaganda which refers to these people unabashedly as a special social achievement of the Soviet Union. Articles in central newspapers and magazines with such titles as "The U.S.S.R.—State of Longevity" promote the legend. Dr. Medvedev cites statements such as the following, appearing in what are purported to be scholarly academic publications, "The Soviet Union is the country with the record longevity of human beings. The number of centenarians is increasing, parallel with our approach to the creation of a Communist Society."

The fact that Joseph Stalin was a Georgian must also be taken into account in the legend of the Soviet centenarians. Stalin himself was very much interested in the phenomenon, and because of that interest, local Georgian authorities were anxious to provide more and more cases of longevous people. But perhaps the most reasonable explanation for the appearance of this phenomenon in the Soviet Union is the likelihood that hundreds of thousands of known deserters and draft dodgers of the First World War and the Russian Revolution (most of whom were from the Caucasus) used their fathers' documents to falsify their ages. In order to maintain the fiction, they have had to continue

[7] Medvedev, Z.A. Caucasus and Altay longevity: A biological or social problem? *Gerontologist*, 1974, *14*, No. 5, Pt. 1, 381-387.

the masquerade, and have exaggerated it even further when the several benefits cited here were likely to accrue.

Who Is Old?

The aged as they are presently defined are culturally anomalous. This is largely because the concept of old age has become absolutely tied to a birthdate on the calendar. This definition of age is entirely removed from the biological reality that the rate of aging is different for different people. There are many who are "old" at 50 and others who are not "old" at 90. The major social dislocations created by assiging old age at a fixed time for all persons is best exemplified by the spurious assignment of a fixed age for retirement—now generally enforced at age 65. This numerology takes no account of differences in rates of aging in individuals, as also is the case for fixed calendar ages in determining adulthood, ability to drive a car, or alcohol consumption.

Old Is Not Beautiful

In America today normal aging is more often than not a process of disengagement in which there occurs a mutual withdrawal of the aged person from society and society from the aged person. It is tacitly assumed that both parties are better off after disengagement has occurred. Yet psychologists and sociologists have demonstrated that life satisfaction of the aged is more highly correlated with the same kinds of social activities that are characteristics of middle age.

In modern industrialized societies there is little doubt that sickness is more frequently found among the old as a group than it is among the young as a group. Disease has come to be regarded as an almost invariable accompaniment to aging, even though the physiological decrements of normal aging may, in fact, be reversible. Such age-related changes as sensory loss, learning deficits, incontinence, confusion, and memory loss may indeed be reversible or controllable.

Gerontologists are beginning to look at some of the societal expectations or the self-fulfilling prophesies that lead so many old people to regard themselves as "patients." Professor Otto von Mering of the University of Florida has described a pattern he has observed in a large university hospital as "growing old the out-patient way." Professor M. Margaret Clark of the University of California in San Francisco has recently described cultural patterns that identify the aged as dependent and which allow them to play one of the only socially sanctioned roles for old people, that of being sick. Professor Clark also suggests that the major fact leading to the identification of the aged as a social problem is concern over their real and potential dependence on the rest of society. The prospect of dependency in old age is frightening to individuals in most industrial countries, but no more so than in the United States where only by being independent can the "American Ideal" be reached. Professor Clark goes on to observe that this cultural imperative forces many elderly people in this country to make an unhappy choice between denial of need for help, on the one hand, and self-recrimination, on the other. Although the degree to which this observation holds may vary from culture to culture, it is probably more prevalent in this country than elsewhere. Professor von Mering concludes that "We have, in effect, traded mortality for morbidity, and morbidity for disability and medicated survival."

Old, Poor, and Sick in America

A sizable proportion of the aged in most industrialized countries are poor. This may be largely attributed to the replacement of an agrarian economy by one based on wage labor. Over 16 percent of older people in the United States had incomes below the poverty threshold in 1973. Almost 60 percent of these poor were living alone or with nonrelatives; of these, the large majority were women, mostly widows.

It is doubtless true that to be old in America is unpleasant, to be old and poor in America is a tragedy, but to be old, poor, and a member of an ethnic minority in America is devastating. Compounding this situation further are factors of marital status and health. Most older men are married, whereas most older women are widows. About 85 percent of older persons not in institutions have one or more chronic diseases, and older people have a one in four chance of being hospitalized during any year, which is twice as great as for people under 65. Once in the hospital, older people stay twice as long as do younger people (17.5 vs. 8.7 days).

What To Do

What is to be done about this situation? Short of extending life expectancy or the lifespan itself, a revamping of society's attitudes toward the aged must take place if we are to halt and hopefully reverse the current situation.

People should not be removed from the work force at a specified retirement age, but only with due regard for the differences in rates of physiological decrements

peculiar to each individual. There are many elderly people who have continued to be productive individuals despite what society has come to expect of the elderly. How have they succeeded where so many of their peers have failed? This is an area of sociological and psychological investigation that could define the sets of conditions that are necessary to increase the numbers of productive elderly.

In the past few years several strong advocacy groups for the elderly and retired have appeared. Such large groups in the public sector as the American Association of Retired Persons, the National Retired Teachers Association, the National Council of Senior Citizens, and the National Association of Retired Federal Employees have assumed leadership roles in articulating the needs of retirees and the elderly. At the Federal level, the Administration on Aging, the Social Security Administration, and the Veterans Administration have been the main organizations concerned with the affairs of the elderly. All these groups deal with the social and economic status of the aged, but do not concern themselves with the fundamental causes of age changes and their possible resolution. The social support system for the aged in this country has now reached a staggering level and still more must be done. It is not too difficult to imagine a society in which the major efforts of most of those under 65 will be directed toward the care of those over 65. We are fast approaching a time when very important decisions must be made in regard to the future of an increasingly greater population of the aged in this country. Our present policies are simply designed to offer symptomatic relief, with very little effort directed toward the fundamental causes of the problem.

The current situation is roughly analogous to policy decisions facing, for example, the National Foundation for Infantile Paralysis in the 1940's and 1950's. Had that Foundation decided at that time to invest all or most of its resources in the perfection of better iron lungs, we would probably have today the best designed, best automated, and exquisitely comfortable iron lungs for tens of thousands of current polio victims. Instead, the Foundation made the decision that a substantial portion of its resources should be invested in the basic research necessary to understand and control the disease. The outcome, of course, is familiar to us all.

Basic research is often a high risk speculative venture, but like high risk speculative stocks, it can result in huge payoffs. It can and often does result in no payoff at all, yet can we afford to neglect it? The development of the polio vaccine has led to complete control of the disease, something that more efficient iron lungs would never have done. In a similar fashion, improvements in the social, economic, and medical support system for the elderly will not result in a better understanding of the fundamental causes of aging but will merely provide that kind of symptomatic relief analogous to the use of iron lungs for polio victims.

Tampering With Our Biological Clocks

If the control of aging is dependent upon understanding the basic biological processes, one profoundly important question arises: How desirable is it to be able to manipulate our bilogical clocks? The answer to this question is not simple. The fact that it must be asked is further evidence of the distinction that must be made between disease-oriented biomedical research and gerontological research. Who would ask: What are the goals of cancer research or what are the goals of cardiovascular research? The answers are so obvious as to preclude asking the question. But the goals of gerontological research are quite a different matter, because we are not certain whether the "resolution" of the physiological decrements of old age will indeed benefit the individual or the society as a whole.

Many different biological resolutions of age changes are possible, and each has an important potential side effect. Take, for example, the possibility that research into the biology of aging might result in the total elimination of all age-related physiological decrements. As already said, if this were achieved, and no control existed on the biological clock itself, the result would be a society whose members would live full, physically vigorous, youthful lives until the stroke of midnight on their 100th birthday—at which time they would die. If, on the other hand, we were to learn how to tamper with our biological clocks, with what goal in mind would one choose to reset his clock? Surely one wouldn't choose to spend an additional 10 years suffering from the infirmities of old age—yet that might, initially, be the only way to intervene. Is society prepared to cope with individuals whose only choice might be between naturally occurring death and 10 or more years spent with the vicissitudes of old age? We can hardly deal with a mean maximum lifespan of, say, 80 years, to say nothing of the further social, economic, and political dislocations that might occur if we add another 10 years.

Aside from this possibility, it is also worth considering the prospect of clock tampering in which the choice would be to spend more years at a particular stage of our lives than we now do. The clock might be stalled for 10 years at, for example, a chronological age of 20. Is

this desirable? Each of us, after pondering this provocative question, would likely agree that the time at which we would like our biological clocks arrested should correspond to those years in which maximum life-satisfaction and productivity occurred. Yet if we were forced to make such a decision it would probably have to be made prospectively. Even more complex is the question of when in the human lifespan individuals are most productive. An interesting and exhaustive study of this question was made by Dr. Harvey C. Lehman in 1953.[8] The conclusion to be reached from his data is that, depending upon the particular area of human endeavor, the time of maximum productivity can occur at any time in adulthood. Thus clock tampering becomes a game that very few of us are capable of playing.

Goals for the Old

Having presented here only a few of the possible goals of biological research in aging it should be clear that a simple answer cannot be given to the question, What should the goal be? Although simple to state and conceptually easy to understand, I have purposely avoided the notion of biological immortality. I have done this for one principal reason—that to attain it is so far beyond any practical realization that any discussion would be science fiction.

The most serious effects of even a modest success by biological gerontologists in increasing human life expectancy would be the societal consequences. Most gerontological sociologists are persuaded that even as little as a 5-year increase in life expectancy would be so profound as to rupture our present economic, medical, and welfare institutions.

In spite of the apparent dilemma in stating goals for gerontological research, one goal appears to be wholly desirable and even attainable as a short-range objective. That is simply to reduce the physiological decrements associated with biological aging so that vigorous, productive, nondependent lives would be led up until the mean maximum lifespan of, say, 100 years. Implicit in this notion is that the quality of life is more important than its quantity.

Of what value is immortality, if by achieving it, one extends the infirmities? Two modern versions of this theme exist in Aldous Huxley's "After Many a Summer Dies the Swan" and Oscar Wilde's "The Picture of Dorian Gray." In fact the Gerontological Society itself has as its motto: "To Add Life to Years, Not Just Years to Life."

[8] Lehman, H. C. *Age and achievement.* Princeton, N. J.: Princeton University Press, 1953.

If longevity is to be increased merely by extending the years of our infirmities, then the goal is not worth seeking. This indeed is the modern dilemma faced by many physicians who are torn between using every means for prolonging the terminal stages of disease in the name of prolonging life, but at the expense of continuing the agony of certain death. The goal that is not only more desirable, but indeed more attainable, is not the extension of longevity per se, but the extension of our most vigorous and productive years. If tampering with our biological clocks ever becomes a reality, it would be tragic if such clock tampering would result only in the extension of those years spent in declining physical and mental health. Having said this, what are the prospects of achieving the goal? I believe that the prospects are beginning to brighten.

Changing Attitudes

It is sometimes observed that there are no gerontologists, just biochemists, cell biologists, and immunologists working in gerontology. Many serious biologists with an interest in aging still hold at arm's length the appellation "gerontologist," either because of the attitude that the problem is simply too complex to yield to experimentation, or because the many pseudoscientific fringe groups in search of biological immortality have had such a pervasive influence that to formally associate oneself with the field is to suffer an unseemly stigma.

Happily in the past few years a significant change in attitude has occurred toward the science of gerontology. There is now the realization that biological aging is no more complex than are problems in embryology, development, neurobiology, cancer research, or genetics. The attitude is untenable that efforts by gerontologists to reverse the aging process are akin to medieval alchemy, for all successful biomedical research has the net effect of prolonging life. Thus there is no rational reason to discourage research on the fundamental causes of age changes. Established investigators are no longer apologetically explaining their interest in aging, and young scientists are beginning to appreciate that the fundamental problems are less intractable than their predecessors thought. Public awareness of this neglected field has led, for one thing, to the creation of an Institute on Aging in the National Institutes of Health.

For the first time the discipline of gerontology has been given a degree of national recognition at the biomedical level, to make real meaningful efforts to understand the biology of aging. The field has now been

given a level of national visibility that is almost compatible with the magnitude of the problem. Even more important is the implication that something can and should be done about biological age changes. The period of utter disregard of the question has now passed.

Prognostications

In any attempt at futurology it is wisest to base predictions on similar events that have happened in the past. To the question, What will be the impact of achieving a 5-, 10-, or even 20- year increase in human life expectancy, we have only to look back at the same question asked in 1900, for it is only during the period 1900-50 that increases in human longevity of these magnitudes did, indeed, occur. It is therefore safe to conclude that any further increase in human life expectancy is likely to incur the same sets of problems and solutions to those problems that occurred in the first half of this century. The question then is: To prepare for a potential increase in human longevity, what should we now do that is different from what was or was not done in 1900? The chief medical problem during the first half of the 20th century was infectious diseases, and the chief biomedical accomplishment during that time was their virtual elimination. As a result society now finds itself burdened with unprecedented numbers of disabled and indigent old people who have survived infectious diseases but who will not survive old age. We do not wish to prolong old age by keeping people alive well beyond their years of vigor. What we want to do is what the science of gerontology is all about.

As to making predictions about the likelihood of increasing human longevity, some consideration should be given to two recent efforts in which such prognostications have been made. In both these studies, the opinions of scientists were elicited. Polls are a poor way to conduct scientific research, but for what it might be worth, the results were as follows: In the Rand Study scientific prognosticators concluded that an increase in longevity of 50 years will occur by the year 2020.[9] In the study by Bender, Strack, Ebright, and von Haunalter a major increase in longevity was considered attainable by the early 1990's.[10,11]

[9] Gordon, T. J., & Helmer, D. *Report on a long-range forecasting study, 1964.* (No. P-2982) Santa Monica, Cal.: Rand Corporation.

[10] Bender, A. D., Strack, A. E., Ebright, G. W., & von Haunalter, G. *Futures*, 1969, *1*, 289.

[11] Ed's. note: These predictions are not accepted by any except a very few gerontologists. As reported in appendix C of this volume, a sample of Fellows of the Section on Biological Sciences of the Gerontological Society were asked in 1974 what they expected to happen by the year 2000 with respect to life expectancy at age 65. Their average prediction was a gain of 5 to 10 years.

Since life expectancy has increased so dramatically in the last half century anyone can foresee the possibility of some small degree of further extension. All that needs to be done is to better the hygienic, health care, and nutritional deficiencies of the substantial proportion of Americans who are now denied these basic human needs. Thus there is no requirement for new intellectual bases of understanding the biology of aging to materially increase the longevity of a substantial portion of our society. All that it takes is motivation and money. This achievement would increase life expectation but, of course, would not affect the lifespan or the rate of aging. Nevertheless, it is something that could be done now without requiring any new scientific innovations.

For significant increases in longevity to take place, spectacular scientific achievements will be necessary.

The consensus of scientific opinion is that the fundamental causes of age changes, like developmental changes, are somehow programed within the genetic apparatus. It is there that the clock is undoubtedly located. A fruit fly is old in 30 days, a mouse in 3 years, and a man in 90 years. The genetic control of these differences is more or less self-evident. The rate of aging per gram of mouse tissue is 30 times faster than per gram of human tissue. Further clues that genetic processes control age changes can be seen from the sex differences in human and animal life expectation. Perhaps the best examples are actuarial data which clearly show that the children of long-lived parents are themselves long-lived. Demographic data lead to the amusing conclusion that the best possible circumstances for achieving maximum longevity are to be a white, highly educated, wealthy, Swedish female with centenarian parents and grandparents. (One wonders what such a women would have to say to her poor old, black, sick counterpart living in an American ghetto.)

The conclusion to be reached, then, is that if, in the next 25 years, biomedical research were to triumph to the extent that deaths caused by cardiovascular disease and cancer would be preventable, a net increase in life expectancy of about 20 years would occur. Advances made in preventing deaths caused by other diseases would not have much impact on human longevity. The greatest potential impact on human longevity would be research directed toward reducing the rate of the fundamental nondisease-related biological causes of age changes, causes which are undoubtedly genetically determined.

If our social, political, and economic institutions are likely to be severely dislocated by these achievements, what right do we have to encourage this kind of research?

Prospects of Lengthening Life and Vigor*,**.

Robert J. Havighurst and *George A. Sacher*

At present the average remaining years of life for Americans aged 65 is about 15 years for men, 19 for women. It is rare for people to live beyond the age of 90, but there are known cases of Americans living to be 110, which seems to be a kind of upper limit. (As pointed out in Mr. Hayflick's paper,[4] none of the claims of superlongevity—of persons who claim to be 120 or 130 or 150—is scientifically valid.)

The concept of a "human lifespan" of about 100 years is a concept that most biogerontologists find useful. It is not the *maximum* lifespan, which remains to be determined empirically; nor is it the *mean* lifespan, or average life expectancy, which is now about age 70 for Americans. The mean lifespan is an established datum for various populations. It has increased greatly during the present century in developed countries of the world, and it will probably increase slowly for another quarter century.

So far as is known, the "human lifespan," in contrast to the mean lifespan, has remained the same over the centuries. A major question is whether the human lifespan can be increased by methods that some biogerontologists are presently pursuing. One group of biogerontologists believes that the human lifespan of about 100 years can be increased substantially through methods of treatment that slow down the "rate of aging" of the cells of the body. Another group, including Hayflick[4] and Sacher, believes that certain forms of treatment and certain improved health habits will continue to lengthen the *mean* lifespan, and will perhaps increase the human lifespan slightly, but that these approaches will not change the "rate of aging."

Life Expectancy

Before examining this issue of the extension of the human lifespan, and what is meant by the "rate of aging," we should consider the changes that have occurred during the 20th century in the *mean* lifespan, or average life expectancy. Obviously, the mean lifespan has already been substantially increased in this country by the prevention and cure of the diseases that formerly led to deaths at relatively early ages. First, the major causes of infant mortality came under control, immediately producing a big gain in life expectancy. Then around 1940 antibiotics came into use against infectious diseases, especially against pneumonia, which had been a major killer of people aged 40 and over. This produced another major increase in mean lifespan.

Since 1950 there has been only about 2 years gain in life expectation in the United States for people who reach age 65. The principal cause of death for American adults is cardiovascular disease, and the next in importance is cancer. It has been calculated that an absolute cure or preventive agent for cardiovascular disease would increase the average length of life for people who reach age 65 by about 10 years, and a similar cure or preventive of cancer would increase life expectancy at age 65 by 1 to 2 years.[5] It is not likely that we will discover a complete cure or preventive, but a 50-percent reduction in the death rate from these two diseases would produce a considerable increase in life expectancy and would greatly increase the size of the elderly population compared to the total population.

*This essay draws upon more technical papers by George A. Sacher.[1,2,3]

**Mr. Sacher's work was supported by the U.S. Energy Research & Development Administration.

[1]Sacher, G. A. The future of biological gerontology: A proposal for evaluation and action. Working paper for the Salk Institute Workshop on Aging, La Jolla, California, July 6-8, 1974. Unpublished.

[2]Sacher, G. A. Life table modification: Ends and means. Working paper for the Conference on Social Policy, Social Ethics, and the Aging Society, University of Chicago, 1975.

[3]Sacher, G. A. Life table modification and life prolongation. Chapter 24, the *Handbook of the biology of aging*, J. E. Birren, L. Hayflick, and C. W. Finch (Eds.). New York: Van Nostrand Reinhold, 1977.

[4] Hayflick, L. Perspectives on human longevity. Paper appears in present volume.

[5]National Center for Health Statistics, U.S. Public Health Service, "U.S. Life Tables by Causes of Death: 1969-71," by T. N. E. Greville, U.S. Decennial Life Tables for 1969-71, Vol. I, No. 5, 1976 (forthcoming).

It has been estimated, for instance, that if all people would quit inhaling tobacco smoke, and would eat less of certain foods, and if air pollution was markedly reduced in the big cities, the death rate due to cardiovascular disease would be cut in half, producing a gain of 3 to 5 years in mean lifespan. Whether or not that estimate is accurate, any improvement in the prevention or cure of certain chronic diseases—the diseases that most frequently attack elderly people—would increase life expectancy.

The Rate of Aging

There is another conceivable way of prolonging life which is now being discussed by specialists in the study of aging. This is to slow down the process of aging within the body. Biological researchers have found that as people grow older, their bodies become more susceptible to the major diseases which lead to death. There must be something going on within the body, an *aging process*, which is not the disease process itself but which makes the body less resistant to disease. If this aging process could be understood, it might be treated so as to delay the process, and therefore give people more years of health and vigor before they become vulnerable to the common diseases of old age.

The possibility of slowing the rate of aging is a topic of disagreement among biological researchers. Some say that the postponement of the process of biological aging is very unlikely; others predict a breakthrough within the next 20 years. Among the optimists is Dr. Alex Comfort, the British biologist, who believes that intervention to postpone or slow down aging is practical and ready to be tested on human subjects. He said, in 1969,

> Direct experiment on the delaying of age changes in man is virtually certain to be in hand by 1975. If the techniques used in rodents prove directly applicable, or we are lucky, even allowing for normal research delays, some agent demonstrably reducing the rate of mature human aging is likely to be known within 15 years.
>
> The net result will be a 10-year extension in health and the productive years of life. At age 70, for example, the average individual will enjoy about the same physical and mental vigor he had at age 60. Most if not all degenerative changes and disabilities will be postposed roughly across the board; cancer, heart disease, arteriosclerosis, etc., generally will occur at a much later age than they do now.[5]

[6]Comfort, A. Longer Life by 1990? *New Scientist*, 1969, *44*, 549-551.

Comfort belongs to a minority of biologists who believe that we can add 10 to 20 years of vigorous health to the average lifespan by slowing the rate of aging; but even most members of that minority believe such an achievement is far in the future, surely much farther away than the next 15 years.*

Most of the relevant research has been carried out on mammals with short lifespans, such as rats and mice. This research on animals is necessary in order to find out what treatments make a difference in lifespan.

"Rate of Aging" Versus the Factor of "Vigor"

Sacher has analyzed lifespan data for a number of organisms including man, and has formulated a mathematical description of the life table.[1,2] To explain his description with a minimum of mathematics, we can look at a set of model survivorship curves as presented in figure 1. The curve *a* approximates the survivorship curve for the adult U.S. population in 1970. (The model does not take account of infantile and juvenile mortality, which for the most part are not related to the aging process.) The proportion of the population surviving to the age of 40 is about 95 percent. After that age, the death rate increases, and the numbers of survivors begin to fall off more and more rapidly. The proportion still living at age 70 is 60 percent. If this part of the curve, from age 40 to age 70, could be kept from falling so rapidly—that is, if there were fewer deaths—then, by definition, the mean lifespan would be substantially increased.

Sacher's mathematical analysis showed that the survival curve is characterized by two parameters or variables, which can be designated as *alpha* and q_o.

The first parameter, *alpha*, is the slope of the straight line that results when the logarithm of the age-specific death rate is plotted on a graph. This tells how rapidly the death rate increases with age, and it can be called the *rate of aging*. It is an empirical fact that for man, after about the age of 40, the death rate doubles about every 8 years. The death rate doubling time is characteristic of the particular species. It is about 200 days in experimental populations of mice, for example, while it is about 3,000 days (or 8 years) in man after man reaches adulthood, a 15-fold difference.

The second parameter, q_o, is needed together with *alpha* to give a full mathematical description of the survival curve. This second parameter can be called the *vulnerability* of the *vigor* factor. It represents the vigor or

*Editor's note: See appendix.

the stability of constitution in the species being studied; or in somewhat different words, the susceptibility to injury, disease, and death that is present in the animal *at birth* and *all* through life. This second factor can be measured, for instance, by the initial death rate, or the death rate that theoretically occurs at birth, before the rate of aging comes into effect. On this measure, the difference between mouse and man is about 500-fold.

The two factors together create the life table. Both these factors vary from one species to another. Both are constitutional characteristics of the body. They are correlated, but the degree of correlation differs from one species to another and is related to body size and to facts about the reproduction of the species. The two factors are partly independent, then, although both have an inborn or genetic basis. Both of these factors can be changed, at least theoretically, by some kinds of treatment that biologists are attempting to discover.

Two Ways of Extending the Mean Lifespan

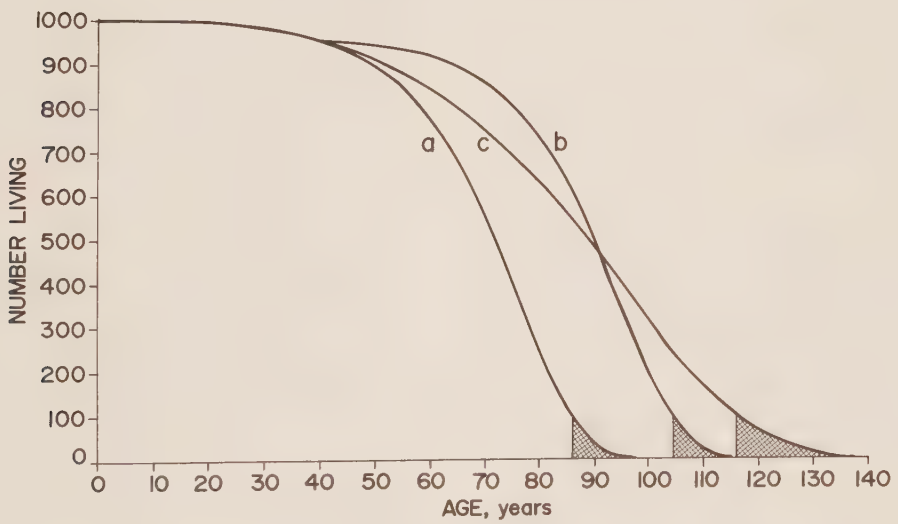
There are two conceivable ways to increase the *mean* lifespan, depending on which of the two factors is involved:

(1) *Slowing the rate of aging*: Turning again to figure 1, the survivorship curve *c* results from a change in the rate of aging or in the *alpha* factor. This curve was drawn on the assumption that the time taken to double the mortality rate after age 40 would be lengthened from the present 8 years to 16 years, i.e., that the rate of aging would be slowed down. This might conceivably result from a breakthrough in aging research of the type referred to by Comfort. One or more substances or methods of treatment might be used by people systematically from age 40 onward so as to increase their life expectancy at age 65 by as much as 15 or 20 years.

Thus far no pharmacological method has been demonstrated that slows down the rate of aging, even in smaller animals. Several "antiaging" drugs or chemicals that have been used with mice and other small animals have prolonged the lives of these animals according to the *b* curve of figure 1 but not according to the *c* curve. That is, the "antiaging" substances extend lives by helping the animals resist the ordinary diseases which cause death, but these antiaging substances do not greatly extend the maximum lifespan of the animal.

There are two kinds of regimes that do extend life for experimental animals by decreasing the rate of aging and that do therefore extend their maximum lifespans. The first is by restricting the food of rats and mice to the point of slowing down the animals' activity; the second is by reducing the body temperature of coldblooded species, insects, and fish.

Fig. 1. Survivorship Curves Based on Various Patterns of Mortality



a. Adult U.S. population, 1970
b. If "vigor" were improved
c. If the "rate of aging" were slowed

How might these methods be applied to humans? It is generally supposed that most people in affluent societies eat too much, and would be healthier if they ate less. But this assumption is based on the facts about the dangers to health of excess fat. Just following a "reasonable" diet will keep a person's weight down to a healthy normal, but it will not slow the rate of aging of the cells in the body. To actually reduce the rate of aging of the cells, it would probably be necessary to reduce the intake of food drastically, or if not the intake itself, at least the body's absorption of nutrients. (The latter might be accomplished by taking pharmacological substances which would prevent the body from absorbing nutrients, even though the person eats all he wants.) The body would not get the nutrition, and would therefore enter a state of slow starvation. This might slow down the rate of aging of body cells, but it would also slow down the body's activity, for the available energy from food would be reduced, and the person would become listless. The question would then become, Would people want to pay this price for an extra 10 years of existence?

The second method of slowing the rate of aging, reducing body temperature, can be carried out with coldblooded animals like fishes, but can hardly be done with humans. When the human body temperature drops a degree or two below normal, the body starts to shiver, which is a way of making the body exercise itself and thus raise its temperature back to normal. Still, biochemists might discover chemicals that would reduce the temperature of the human body by, say, five degrees, and thereby slow down all body processes, including the processes of aging of cells. But this would make the body less active, and reduce what Sacher refers to as *productive energy output*. The body would slow down, all mental and physical body processes would slow down. Again, would people want to extend their lives by this method?

(2) *Improving "vigor"*: The survivorship curve *b* is based on the assumption of a change in the *vigor* or vulnerability factor. This change can be brought about in two general ways: One way is by improved health practices and health services. Increased vigor and decreased susceptibility to disease have, of course, been going on at all age levels, although very slowly among persons 65+. As mentioned earlier, the use of antibiotics has been one of the ways in which mortality has been greatly reduced; and various public health measures have had the same effect. For present purposes, however, we are speaking of health practices that might begin at age 40, when, for example, reduction of cigarette smoking, maintenance of low cholesterol diets, and improved medical services might produce new reductions in susceptibility to disease or new increases in the vigor factor.

Another method of increasing the vigor factor might be use of drugs or pharmacological agents which are not specific treatments for specific diseases, as antibiotics are, but which have more generalized effects on bodily vigor. Sacher[3] has reviewed the experimental work with such drug treatments on mice and other small animals, and finds that they do increase the vigor factor, thus lengthening the average lifespan of these animals. However, such treatments have not yet been shown to affect the mean lifespan in man, although several substances are now being used experimentally with humans in pursuing this goal.

The survivorship curve *b* in figure 1 is based on the assumption that death rates will be reduced to one-fifth of their present values after age 40, whether the reductions come about by changed health practices or by the use of pharmacological agents. To increase the vigor factor to the extent shown by curve *b* would increase the mean lifespan, or average life expectancy, at age 65 by about 18 years. This hypothetical reduction is much greater than we can realistically expect, but it serves to make clear the possible effects of reducing the vulnerability factor.

Comparing the Two Methods

Comparison of the two hypothetical survivorship curves *b* and *c* shows some important differences. A change in the *rate of aging* (curve *c*) would not reduce mortality very much in the period from age 40 to 65, or in other words, for the first 25 years after people of 40 would begin the treatment. After age 65, however, and especially after age 80 the effect would become more pronounced. This method of reducing mortality would extend the *mean* lifespan, and it would also extend the "human lifespan" from the present 100 years to something like 130 years.

A change in the *vigor* factor (curve *b*), on the other hand, would save lives from the time it started at age 40, and it would save more lives than the method of rate control up to age 90, where the two curves cross each other. It would then save fewer lives from age 90 onward.

Thus curve *b* saves more lives between ages 40 and 90, while curve *c* saves more lives between ages 90 and 110. Curve *b* would extend the *mean* lifespan from about 70 to about 90, as already mentioned, and it would also extend the "human lifespan" from the present 100 years to about 115 years.

Curve *b* is more nearly rectangular, with a higher shoulder at the ages from 50 to 90. This type of survivorship curve would probably be more satisfactory than curve *c*, from the standpoint of the community and the individual, for the period of low mortality and low morbidity would be extended, while the declining period of life, the period of high morbidity after 90, would be shorter. With curve *b*, there would be a bunching of deaths in the last 10 or 15 years of the lifespan. Curve *b* is also more "determinate" in the sense that persons could more often predict the approximate age of their deaths.

The Problem of Disability and Life Extension

A question of enormous social significance is, What will happen to the amount of physical disability in the elderly population if an extension of life is achieved? Will there be increased need for medical care, increased need for long-term care, increased years of physical or mental disability?

From the survivorship curve *a* of figure 1 we see that, by age 50, the mortality rate is substantial and doubles every 8 years. From this age on, there are increasing amounts or lengthening periods of physical disability, due mainly to increased morbidity from chronic diseases. The following diseases show increased incidence, and they tend to cause more and more disability: cardiovascular disease, cancer, cerebral accidents (stroke), arthritis, rheumatism, and failing eyesight.

In addition, there are two other major causes of disability: senility and the kinds of accidents that result in broken hips and other conditions that reduce physical mobility. Senility perhaps should be regarded as a disease entity—some form of deterioration of the brain occurs, and it may progress to a point where the person can no longer care for himself.

As a result of these various diseases and disabilities, a sizable number of persons over 75 are placed in institutions where they receive such physical and medical care and such general supervision as they need. This has been an increasing number, although the number may be stabilizing at a relatively constant proportion of the over-65 population. This group includes practically all residents of nursing homes who are over 65, and a portion (but not all) of residents of homes for the aged. It also includes a portion of the residents of State and private mental institutions.

The total number of elderly people in need of physical care and general supervision—both in and out of institutions—is estimated at between 10 to 15 percent of the over-65 population, or 2.6 to 3.3 million in 1975.[7]

The proponents of both methods of lengthening life—changing the vigor factor, and changing the rate of aging—say that they will lengthen the active and vigorous part of life. That is, they say that by appropriate methods of treatment it is possible to stretch out the *active and useful* life without increasing the period of physical disability. But the evidence for this proposition is scanty, whether it be related to one method or the other.

It seems reasonable to suppose that with more effective methods of preventing or curing chronic diseases, older people will retain their physical activity and vigor longer. For example, if hypertension and other forms of cardiovascular disease are reduced, the physical disabilities connected with these diseases will be reduced, and people will live longer without any net increase in the amount of disability. On the other hand the disabilities attached to arthritis, rheumatism, and failing eyesight may increase as people live longer, and new treatments will be needed to reduce their incidence.

The proponents of the rate control method of extending life say that if all the living cells of the body age more slowly, the body will stay fit for a longer period. Thus a person who is 90 years old but who has undergone treatment to slow down the rate of aging will be as vigorous at 90 as he would otherwise be at age 75. His eyesight will not deteriorate as fast as it would under present-day conditions, his teeth will hold out longer, and his arthritis will not be as painful. Yet the 90-year-old will be subject to the "accidental" causes of disability, such as infections and accidents, and these will require health care and medical treatment.

Sacher argues that there is nothing in the theory of action of antiaging drugs to indicate that a reduced rate of aging will be accompanied by a reduction in morbidity, or in the average duration of time a person stays alive with a terminal disease.[2,3] It seems reasonable to believe that the amount of medical care and health service needed by a particular elderly subgroup is bound to increase with the age of that subgroup, no matter what kind of antiaging treatment or preventive health care it has received. The amount of disability and dependence upon care by others is sure to be higher for the oldest 10 percent of the population than for

[7] U.S. Congress Senate Special Committee on Aging. *Report on Nursing Home Care in the United States, December 17, 1974. Supporting paper # 1.* Washington, D.C.: Government Printing Office.

younger age cohorts, and if the last survivors live more years, as they clearly do for the *c* group in figure 1 (compare the shaded areas under the three curves), they will in all probability require a greater total amount of health care and service.

It is difficult to believe that the average length of life after age 65 could be extended by either of these methods without a substantial increase in the number of visits to the doctor or dentist, the number of days in the hospital, and the number of nursing home beds.

From these considerations it appears that, above all, we need more studies of the physical vigor and the health care of the population beyond age 80 or 85. Among other things, we need to examine the kinds of preventive health care and treatment persons receive after age 40 or 50.

We may be fairly sure that the average lifespan beyond age 65 will be increased by the year 2000, whether it be by 2 years or 5 years or 15 years. Many more people will live into their 80's and 90's, and their health and happiness will be influenced by research in biogerontology.

Extension of the LifeSpan: A National Goal?

James L. Goddard

In the United States today there are several thousand individuals who are over 100 years of age.[1] The probability of any of us joining that select group is very slight in spite of the astonishing advances made in the medical sciences in recent decades. Most of us will, in fact, have to be content with the traditional three score and ten as evidenced by today's average age of death for men at 69½ years, and for women, 75⅔ years. There are those, however, who believe that these averages can be substantially increased in the not too distant future through the development of methods to slow the rate of aging. If so, becoming a centenarian could become the norm rather than the exception. What lies behind this belief? What would be involved in accomplishing such a change? What ethical and social issues would confront society if such a development were to occur?

The belief that it might be possible for man to extend his lifespan seems to be age-old. Its roots are in the myths and religions of early societies and in the early era of modern man, when it was observed that some individuals lived many decades beyond their contemporaries. Such observations led alchemists during medieval times to seek a magical formula, led explorers such as Ponce de Leon to search for the "fountain of youth," and in the late 19th and early 20th centuries enticed scientists to undertake investigation of the phenomena associated with aging in the hopes of discovering a method to prolong life. Metchnikov, of the Pasteur Institute in Paris, published in 1903 a treatise called "The Nature of Man" in which he set forth the hypothesis that autointoxication caused by bacterial pathogens in the digestive tract was the major factor in the mechanism of aging.[2] He was wrong, but his work was an early landmark in the study of the processes involved in aging (more commonly called gerontology, as opposed to geriatrics which is a study of the diseases of the aged). Since then the scientific community and the public at large have periodically been exposed to new "discoveries" which held forth the hope that man's cherished dream of postponement of death was indeed at hand. In turn we have witnessed the rise and fall of the yogurt diet fad, the era of glandular transplants, cytotoxic serum, and the current rages of cell therapy and Gerovital.[3] Over this same period of time less spectacular but more important developments have occurred which must be appreciated in order to understand why many scientists feel we are in a position to tackle the job of extending man's lifespan.

New Research Directions

First of all, scientists have been conducting laboratory experiments on a variety of nonhuman species throughout most of this century in an attempt to understand the aging process and how to alter it. These experiments have resulted in a substantial body of knowledge which suggests that life processes can be extended beyond their normal range. Some of the more significant experiments and their implications are these:

(1) Cooling experiments, reported as early as 1917, indicate that lowering the internal temperature of an organism will result in longer life. One such study showed that a common pond organism, the rotifer, if kept in water 10°C below its normal environment will almost double its lifespan. Currently there is considerable interest in determining if alteration of the temperature-regulating mechanisms of subhuman primates to achieve a lower internal temperature will produce increased longevity. Results to date indicate that the internal temperature of monkeys can be lowered by 7°F.

The potential of this approach is that scientists estimate that a 3°F decrease in internal body temperature

[1]Ed's. note: The number of centenarians in the United States has probably been overstated in recent censuses. Various methods of estimating their number are discussed in a recent paper by J. S. Siegel and J. S. Passel, New estimates of the number of centenarians in the United States. *Journal of American Statistical Association*, 1976, *71*, No. 355, 559-566. Their preferred estimate is 4,800 centenarians for 1970, 3,300 for 1960, and 2,300 for 1950.

[2]Metchnikov, E. *The nature of man.* New York and London: G. P. Putnam's Sons, 1903.

[3]Cherry, R., & Cherry L. Slowing the clock of age. *New York Times*, May 12, 1974, 20.

of humans could extend life by as much as 30 years. How long the lower temperature can be maintained in monkeys is yet to be determined, and whether the change will indeed enhance their longevity.

(2) Changing the ability of animals to resist infections has been tested through manipulation of their immune systems in order to prolong life. Old mice when injected with virulent bacteria die off very quickly; but when protected by the injection of selected cells from young mice, the same dosage levels of virulent organisms are not lethal and the mice live on for several more months with this "acquired immunity." Similarly in experiments in which the thymus gland of a young mouse is transplanted to an older mouse, along with bone marrow cells and the spleen, the recipient's ability to combat infections and live longer is enhanced. A comparable effect has been produced by extracting a hormone, Thymosin, from the thymus glands of young mice and injecting it into older mice. The importance of this hormone in man is as yet unknown, but it has been reported that the level of Thymosin decreases significantly during the middle years of life and thus may set the stage for the initiation of the aging process.

(3) Experiments with rats and mice have demonstrated that sharply reducing their caloric intake throughout their early life will enable them to live as much as 30 to 50 percent longer. The implications of such findings for humans is uncertain. It has been noted that persons surviving to very old age are usually lean and have generally been moderate throughout life in their dietary intake, but extrapolation from such meager data is not sound.

(4) Dietary experiments have also been carried out involving the use of additives of varying types. The addition of antioxidants in order to combat "free radicals" within the body cells is a method that has been used by a number of researchers. The "free radicals" are fragments of molecules which are thought to combine in deleterious ways with other intracellular elements and thus cause cell aging. The addition of an antioxidant such as vitamin E has been tried in an experiment involving mice, but it had no effect on lifespan. Other antioxidants have been tested in a similar fashion and several have resulted in extending life. One of these tested, dimethylaminoethanol, prolonged life by as much as 40 percent when fed to young mice. None of the chemicals tested in this fashion have as yet been used for trials in humans, although it is not unlikely that such a trial could be carried out in the near future.

(5) Scientists have developed new techniques to study aging which permit greater insight into the processes involved. The most significant of the new techniques involved that of studying cell behaviour in the laboratory. With the ability to grow generation after generation of cells derived from human or animal tissues, scientists can undertake a wide variety of experiments which had previously been impractical or impossible. Without presenting a comprehensive review of the field of molecular biology it is difficult to appreciate the substantial accomplishments which have followed. Two brief statements will hopefully provide some insight into this area:

(5a) The discovery by Dr. Leonard Hayflick in 1961 was a milestone; namely, that normal cells grown in laboratory culture systems have a finite capacity for reproduction before they deteriorate, show changes characteristic of aging, and die.[4] Prior to his now classic experiments it was assumed that cell lines could be maintained indefinitely in the laboratory, provided the proper nutrients were supplied and provided that the environment was carefully controlled. Dr. Hayflick not only demonstrated the fallibility of this assumption, but also showed, along with other experimenters, that the capacity for cell division varies with the species involved and is related to the longevity of the species. Thus the longer the species lifespan, the greater the number of cell divisions before death occurs.

The underlying implications of Hayflick's findings are indeed substantial. We may well possess within our body cells a "biological clock," genetically preset, which determines maximum age. If so, it may be possible, using normal human cell systems, to discover ways to safely alter the rate of aging within the cell without having to understand the basic cause(s) of the changes which occur with aging. This could greatly facilitate the discovery of an antiaging agent or technique.

(5b) The technology has been developed to study in exquisite detail the inner workings of the cell, including its genetic material. Just how complex the processes are can be appreciated by contemplating Dr. Samuel Goldstein's description of the role of genetic factors within the cell. "Every cellular component, whether it is the surface of cytoplasmic receptor for a drug, hormone, or nutrient, an enzyme, or a structural component, is coded for by genes. The same applies to other gene factors exported from cells, including hormones and interstitial factors such as collagen and related ground substances that heretofore had been regarded as

[4]Hayflick, L., & Moorhead, P. S. The serial cultivation of human diploid cell strains. *Experimental Cell Research*, 1961, *25*, 585-621.

informationally inert."[5] These new techniques involving normal cell culture lines, microanalysis, electron microscopy, and genetic manipulation have fostered the development of a new area of gerontological research which Dr. Hayflick has termed "cytogerontology," meaning the study of the aging processes in cultured cells. The cell is, according to Hayflick, ". . . where the gerontological action lies."

Theories of Aging

From the expanded research permitted by the development of these approaches over the past several decades, a host of clues to aging have emerged which have led to the development of several theories as to cause(s). The major theories now being tested include Hayflick's concept that lifespan is limited by a "biological clock" within the cell which permits a finite number of cell divisions before deterioration sets in and cell death occurs; a genetic program within the cells which "runs out" and ceases to provide information to the cellular components, thus causing disorganization and malfunction; and an "error" theory which says that mistakes occur at a low rate throughout the life of a cell and their accumulation reaches a lethal threshold.

Which theory will prove to be correct is, at this stage, relatively unimportant. What is of significance is that the field of gerontology has advanced to a stage where a theoretical framework has been formulated for its future research efforts. With a theoretical framework, based on a substantial body of experimental data, and with a highly sophisticated technology, we seem to be in a position to move rapidly towards fulfilling man's age-old dream of extending life.

The Low Priority of Aging Research

When one examines the resources being allotted to the field today, it is quickly apparent that aging research is a relatively low priority at the national level.[6] We will have spent, depending on how one defines the field, between $15 and $25 million during fiscal year 1975 on gerontological research. It has been estimated that we spend 2 dollars in cancer research for every 3 cents spent in research on aging. This disparity is due in part to the relative newness of gerontology as a special field of interest. It is due also to the absence of major public support groups, such as the National Cancer Society or the American Heart Association, who, along with leaders from the professional organizations within these fields, lobby effectively for the limited funds available from both public and private sources.

Another factor is that aging characteristically has been viewed as an inevitable consequence of living and not subject to attack in the same fashion that enabled us to eliminate polio and other communicable diseases. Only within the past 5 years have we begun to hear experts voice the opinion that aging, although a normal physiological process, can someday in the not too distant future be deferred or even perhaps eliminated. Some of these statements are noteworthy because they constitute unique appraisals of the field of aging, or they express expert views of what our goals should be, how successful we may be in our endeavors, and when a significant breakthrough may occur

> For example, Dr. Nathan Shock, Director of the Gerontology Research Center of the National Institute on Aging, recently stated "We are not interested in our laboratory in increasing the lifespan. I don't buy that as a legitimate goal. I'd rather make the years that we have into good years."[7]
>
> Dr. Leonard Hayflick has said "The goal that appears to be not only more desirable, but indeed more attainable, is not the extension of longevity per se, but the extension of our most vigorous and productive years."[8]
>
> Dr. Alexander Comfort, former director of the Research Group in Aging of University College of London, has commented "The aging process can be slowed down,"[9] seeming to suggest that not only would the middle vigorous years of life be extended but also that the lifespan would be increased in the process.
>
> Dr. Ivan Asimov suggests that by understanding the biochemical and biophysical process, we may by the year 2000 ". . . face a future society in which men and women will routinely live to be over 100, perhaps far beyond 100."[10] Others in this field are even more optimistic as to what can be accomplished.

[5]Goldstein, S. Biological aging: An essentially normal process. *Journal of the American Medical Association*, 1974, *230*, No. 12, 1651.

[6]Hayflick, L. The strategy of senescence. *Gerontologist*, 1974, *14*, No. 1, 39.

[7]Reported in a column by Victor Cohn, *Washington Post*, March 16, 1975, p. C-2.

[8]Hayflick, L. 1974, op cit.

[9]Comfort A. We know the aging process can be slowed down. *The Center Eclectics*, No. 11, 1974. Center for the Study of Democratic Institutions, Santa Barbara.

[10]Cohn, V., 1975, op cit.

Pierre Auer of France has said, "Death may be a manipulable genetic characteristic."[11]

Dr. Bernard Strehler of the University of Southern California has been quoted as saying "Someday we may live indefinitely."[12] It is obvious that Dr. Strehler does not hold the view expressed by one skeptic Dr. Sobel, who said "Man will, if present research trends continue, be able to live for 300 years, 50 years of virility and 250 years of senility"[13] for Strehler says ". . . there is no way to appreciably increase the lifespan except by improving the body's physical state."

As to the probability of success, there is substantial agreement among the experts. Dr. Hayflick has said "The notion that the biology of senescence is too vastly complex to yield to experimentation is, I believe, a myth."[14]

Dr. Alexander Comfort has predicted the probability of a breakthrough as being ". . . one hundred percent, given the time and resources," and ". . . we shall probably get the method of altering the rate of aging before we get the theory." On the timing of the breakthrough, he said that by 1990 ". . . we will know of an experimental way of slowing down age changes in man that offers an increase of 20% in lifespan."[15]

Given these perspectives, it seems that at this juncture we should seriously consider altering our national priorities to provide the funding necessary to ensure a reasonable chance of fulfilling man's age-old dream. How can this best be done? Should we, as has been suggested, establish the extension of the lifespan as a national goal for the year 2000?

Adopting a National Goal

The process of establishing a national goal is much more complex than generally recognized. It usually requires a coalition of outstanding leadership, strong political support, the presence of strong vested interests, a constellation of pressures which combine to cause substantial public support, the economic wherewithal, and in those few instances which have involved science, the existence of a capability which can reasonably be expected to lead to a successful outcome. Thus in the instance of the space program we had the leadership of President Kennedy, the public appreciation which had been heightened by desire to outdo the Russians, the political support stimulated by the vested interest groups, and the underlying scientific capability.

Obviously not every element is required before a goal can be adopted, as witnessed by the Manhattan project initiated just prior to the outbreak of World War II. National Health Insurance is an example of a seemingly desirable national goal which we have consistently failed to adopt, in spite of substantial public support, economic wherewithal, and technical capability. The lack of outstanding leadership, the lack of strong political support, and the presence of powerful vested interest opposition have been more than enough to preclude its adoption.

What then would be involved in adopting the extension of the lifespan as a goal for the year 2000? A prime requisite would be the presence of outstanding national leadership. Without it sufficient public support will be lacking. The leadership may come from an individual, such as a national political figure, or from an organization. (The National Polio Foundation comes to mind as an example of organizational leadership, although the conquest of polio had the added advantage of President Roosevelt's personal interest and support.) A more remote possibility is that the "leadership" would come from industry.

A second prerequisite would be creation of substantial public support. How easy this would be to obtain is difficult to assess. My own experience in discussing this issue with groups of scientists and academicians during the past 3 years leads me to believe that widespread public acceptance can be obtained. There are, however, ethical and social issues to be considered.

Ethical Issues

One of the ethical issues certain to be raised is whether it is right for man to alter life processes in such a profound fashion. It can be anticipated that philosophers will present a range of opinions on this issue. Yet it would seem for the most part that our society, and Western societies in general, have accepted medical intervention for the improvement of health and the preservation of life as a part of their ethos. Paradoxically, this view is so widely accepted that we are now, because of technical innovations, confronted with the ethical issue in dealing with terminally ill patients of their "right to die." An extension of that ethical issue would no doubt arise in the future if the life-extending process were to involve an irreversible change such as a

[11]Cohn, V., 1975, op cit.

[12]Cohn, V., 1975, op cit.

[13]Sobel, H. In E. Palmore & F. Jeffers (Eds.). *Prediction of life span: Recent Findings*. Lexington, Mass.: D.C. Heath, 1971, p. 275.

[14]Hayflick, L. 1974, op cit.

[15]Comfort, A., 1974, op cit.

surgical procedure in early adulthood, or an alteration of the genetic coding instructions within the cells. Would euthanasia be available in later life, if desired? To whom, and under what circumstances? This issue would not arise if the life-extending process were to be not only voluntary but controllable by the individual, such as would be the case if one were to take pills each day.

A somewhat different ethical issue would present itself initially. Are we justified in adopting extension of the lifespan as a national goal in view of our current domestic and international problems? It seems certain that arguments will be advanced that adoption of such a goal would be unethical—because of the potential impact on world population; because of the need to enhance the quality of life for today's elderly before reaching for a new goal involving aging; because of the serious disruption to health care services in the future; and so on. The reasoning would be that a society must solve its existing ills before taking an action which could produce new problems.

But societies, as we know, do not operate in this fashion, and it would be no more unethical to adopt life extension as a national goal than one calling for a permanent Earth colony to be located on the Moon. More appropriate would be such concerns as, How much of our resources should we commit? What changes would these resource commitments generate? What types of changes would be expected in the future with respect to the individual, the family, and society?

Changes in Biomedical Research Programs

If life extension were to be adopted as a national goal, the most immediate changes would involve our current biomedical programs with respect to research and training programs. We have in recent years substantially increased the funding for research and training related to the first three causes of death—diseases of the heart, malignant neoplasms, and cerebrovascular accidents. Our funding in these three areas accounts for almost 50 percent of our current total health research investment, but in terms of what is spent on health care *services* (as estimated $94 billion in 1973), it is a fairly modest amount. To have a reasonable chance of reaching the goal by the year 2000, it may be necessary to expend as much as $25 billion in total, or slightly less than the amount spent by the space agency in its program to put man on the Moon.

Could we expend funds at this level and not adversely effect the efforts to discover causes of heart disease, cancer, and stroke? It seems doubtful that both efforts could be sustained at such high levels, especially during the early years—not from the point of view of impact on the national budget, but because we are limited largely by the availability of qualified persons to conduct the necessary research. Many of the persons now involved in cancer and cardiovascular research would be the very ones most needed in the new effort. It would therefore be essential in the early phases to underwrite a very substantial training program, beginning at the college level and extending through pre- and postdoctoral levels. Only through substantial investment, perhaps as much as $5 billion over the next 10 to 20 years, could enough personnel become available to implement the research program at an optimal level.

To minimize the disruption in both research and training, an assessment of our resource allocation would be required which would permit a redefinition of priorities in light of the new goal; the identification of current programs and projects which fit within the new scheme of priorities; the exposition of areas requiring research effort; the definition of short- and long-range manpower requirements; the matching up of capabilities and interests of organizations and individuals with the tasks to be performed; and the institution of a management system which would couple an appropriate degree of monitoring sensitivity with the capability for periodic reassessment and redefinition of tasks.

Human Trials and Ethical Problems

One special aspect of the experimental phase is worthy of note. It seems almost certain, as the research programs expand and the efforts to determine cause(s) of aging intensify, that one or more developments will occur which will suggest the feasibility of human trials even though the basic cause(s) of aging has not been determined. As a result of cell culture studies, and of trials in one or more short-lived species of animals, an agent or technique (relatively nontoxic) will be demonstrated to prolong life. Are there any ethical issues to be resolved before undertaking long-term clinical trials in a selected population of humans?

No matter how many tissue cell lines are used, no matter how many mice, rats, guinea pigs, dogs, and chimpanzees will have been used in testing efficacy and safety, we will be confronted with not knowing how safe or how effective the approach will be when applied to humans. The same, of course, is true today with regard to all new drugs, but here we are generally dealing with pathological conditions, and usually ones which will *not* require long-term administration, or we are dealing with conditions where the drug used will not produce

an effect which may last for the remainder of the person's life. But in extending the lifespan we will be attempting to alter a normal physiological process, either by a one-time irreversible process or by administration of an agent over a prolonged period of time, perhaps the remainder of the person's life.

How will we select persons to be included in the initial trials? Much will depend on the nature of the data derived from tissue studies and animal trials. If the data show that the method extends life even when first used late in the lifespan, we would be able to minimize the risk in human studies. We would first test the method in persons age 75 or more, and as experience warranted, we would gradually reduce the age of entry into the test group in a stepwise fashion. Each new age group would then be followed carefully to determine that the only significant change was a decrease in the rate of aging. All other physiological processes, including those involved in reproduction, should remain normal and there should be no unusual incidence of tumors or other pathological processes.

If, however, animal data suggested that benefits could only be obtained if treatment were instituted in early adulthood, a different approach would need to be used. Then indeed there would be some thorny issues. Could we ethically recruit volunteers when the risks would be so poorly defined and the benefits so long deferred? This would be quite unlike the trial, say, of oral contraceptives, where long-term risk was undefined, but where the short-term benefits were highly desirable to the participants.

Even if we could recruit sufficient volunteers, we might be faced with the difficult problem of maintaining their interest in participation over the long period required. Especially difficult would be to ensure compliance if daily medication were to be involved. Could we ethically in this instance offer any additional incentives without beclouding the risk issues? Would we be justified in encouraging the use of special groups such as prisoners, to overcome some of the methodological problems? Would we be forced to again start testing with the 75-year-old persons and gradually work down to the age groups most apt to benefit, in order that safety could be assured? If so, how could we justify exposure of participants to unknown risks when there would be no reasonable expectation of benefits for the individual?

In the event a surgical procedure were involved, such as the implantation of crystals into the temperature regulating center of the body, no social controls exist today comparable to the controls developed in the field of drugs. No institutional review programs exist in hospitals, medical schools, or large clinics to review in advance whether the new procedure to be tested is appropriate, or whether adequate safeguards for protecting the rights of the individual have been provided for. This is also an issue which would have to be resolved.

If the agent proposed for trial were a chemical, then the approval of the U.S. Food and Drug Adminstration would be required before any clinical trials could take place. FDA requirements call for proof of safety and efficacy through animal experimentation. Once these minimal requirements are met, an exemption from the new drug regulations is issued (Investigational New Drug Approval, or IND) which permits the trial to be started on humans. In the normal course of events, with successful completion of the trial, an approval from FDA could be obtained by a private firm, without awareness of this fact on the part of the scientific community or the general public. A handful of overburdened medical officers, pharmacologists, and chemists in FDA could make a decision which would have inestimable effects upon future societies.

Is this FDA process any longer adequate? Must we not be concerned with more than safety and efficacy? Should we not at an early point involve a broader spectrum of the scientific community? If an effective method is perceived as being probable, should there not be provision for consideration by social scientists, politicians, ethicists, and theologians? It has been my concern for almost a decade that our present system is inadequate to appropriately assess the highly sophisticated drugs and devices being developed by the scientific community. The existence today of a valid Investigational New Drug Exemption to permit assessment of an agent with potential for life extension adds considerably to my concern for the adequacy of the system. Should this not be the occasion for a reappraisal of the FDA's role?

One final note of caution concerning the human trials needed to demonstrate safety—the numbers of participants needed would be very substantial. This is related to the need to detect changes in the rate of occurrence of rare events, such as malignant tumors or diabetes, in order to properly assess safety. It would be even more important that all foreseeable precautions were taken at the outset, and that the utmost efforts were made to ensure proper followup throughout the trial. Finally, we would need to accept at the outset the possibility that some of the participants would be adversely affected. Should we not be prepared to provide

appropriate compensatory benefits? How this could be done without unduly influencing the judgments of potential volunteers is another unresearched issue.

The Aftermath

Successful conclusion of the research phase, and validation of a method to defer aging, will create a new problem and many important social issues will arise. If one assumes usage by those age 40 and over, and if one assumes that optimum benefits, in terms of number of years by which life will be expanded, would decline according to the age at which use is initiated, then it is apparent there will be a lag period between introduction of an agent or technique and the time of maximum impact as measured by survivors in the population. The precise period of time will be a function of the rate change generated by the agent and extent to which it is utilized. However, it would not be unreasonable to assume that the minimum time available for adjustment would be roughly 40 years. At first blush this would seem to be more than adequate for even significant social change to occur, but when one begins to assess the nature and magnitude of changes that an age-retarding agent would induce, 40 years may indeed be grossly inadequate. What types of changes could reasonably be expected to occur, and what social issues would they generate?

The most obvious change would be the impact on the population group over 65 years of age. The change in lifespan by 20 to 25 percent (or 15 years on the average) would markedly increase the proportion of persons over 75 years of age, and it would noticeably affect the numbers in the 65-74 age group. (Even without any such antiaging treatment, the over-65 age group in this country is expected to constitute approximately 15 percent of the population by the year 2040—this assumes no improvements in death rates due to better health habits or improved health services, and it assumes a birth rate equal to that of 1972.)

With the increase in the over-65 age group, there would be an increased demand for health and social services. The magnitudes of these increases cannot be specified with great precision, but they would be substantial. When we realize that today, in spite of our current emphasis on acute rather than chronic health care, some 27 percent of all health expenditures are made for care of the elderly (now 10 percent of our population), we can easily visualize what would be involved if there were to be any significant lengthening of the lifespan. If we are successful in the intervening years in developing means of coping with chronic illnesses, in providing adequate home health and social services, and in developing a modicum of preventive services, it is not unreasonable to assume that the health care industry would become the major industry in our society if life were to be extended by 20 to 25 percent. (This, despite the desideratum advanced which stipulates that any method of extending life is not worth developing unless it extends the useful vigorous years, and not merely the years of senility.)

The increased lifespan would require substantial adjustments in retirement income programs of all types, if adequate income levels are to be maintained. An increased demand for housing of all types would occur as the population expands; and if present trends towards separate housing for the elderly continue, there would be a substantial requirement for new construction after the year 2040.

Less obvious are changes that might occur with respect to family structure, life styles, especially with respect to leisure time, educational patterns, work patterns, and political processes. One could speculate that with greater longevity assured, divorce might increase and new partnerships might be formed after the end of the child-rearing years. Multigenerational families, of five generations would become more common. This would pose new problems: What kinds of relationships would exist between generations so greatly separated, not only by years, but by life experiences? Life styles would be expected to change markedly in response to changes in work patterns and educational patterns. If, as postulated, work weeks would be truncated, and two or perhaps three careers would become the norm, then education and leisure activities would assume greater importance throughout life than they do today. With a greater proportion of the population over 55 years of age, one could reasonably expect that political processes would be biased towards the elderly. Beyond these potential changes lie many others which would be even more taxing upon our society.

The social issues which such changes would create are even less predictable. What type of income distribution system would be necessary to accommodate the varying needs and demands of the expanded society? Could enough employment opportunities be generated to permit the labor market to operate in essentially the same fashion as it does today, or would we be forced to some new system of job allocation with built-in requirements for periods of community service and reeducation, in order to preserve some semblance of equity? What could be done on an international basis to prevent excessive population growth as usage of the anti-

agent agent? What could be done to foster a reallocation of resources to minimize the possibility of nuclear blackmail by the have-not nations? How could we alter the "Protestant work ethic" to stimulate the intelligent use of the increased amounts of leisure time available? Would we adopt a permissive attitude towards euthanasia for those who find the quality of life during the extended years not worthwhile? Would use of the life-extending technique be restricted, or available to all? If restricted, how would we select those to benefit? Would we consider it a privilege, as we do voting rights, and deny it to any who commit felonies?

Others, more perceptive than I am with respect to the social sciences, can enlarge upon the partial listing of changes which might occur and the issues which could arise. It is apparent even with this incomplete listing that the disruptions to our society would be serious unless appropriate measures were to be initiated at the earliest signs of success derived from the limited human trials.

How concerned should we be that the scientific endeavor now underway will be successful? When are we likely to have our first trial of an agent or method on humans, and when would we be likely to have the method available for all? In my opinion, there is a high probability of success. The indications are now that one chemical currently under study could be tested within the next 2 to 3 years if funds become available. Others will certainly follow. The early efforts may fail, but if we expand our research base and adopt the extension of useful life as a national goal, it seems likely that by the year 2000 we will have completed the initial trials in humans and be on the threshold of accomplishing man's cherished dream. As for today, perhaps it is appropriate to remember the advice given by Carlyle, who said, "Our main business is not to see what lies dimly at a distance, but to do what lies clearly at hand."

Extension of the Active Life: Ethical Issues

James M. Gustafson

In order to write a fully satisfactory assessment of the issues of ethics and human values that emerge from the prospects for the extension of active life, some conditions are necessary that cannot be met at this time. First, insofar as a critical assessment is to be made of the benefits and the deleterious consequences of the extension of active life, certain data needed for evaluation are not readily available. One would need to know what would be the actual consequences for individuals, for particular societies, and for the human species. If such information could be developed, there would be a better factual basis in which to raise the more particular ethical questions of what consequences are to be judged to be of value, or of value to whom and for what. My limited study of the literature available, and the hypothetical character of much of that literature both militate against accurate and precise analysis.

Second, while there is literature that makes evaluative judgments about the consequences of life extension and raises consciousness about the need for evaluative studies of the consequences, neither moral philosophers nor moral theologians have given much attention to this arena. If one compares the amount of literature on clinical medical problems as moral issues, for example, with literature on social policy with reference to aging, it is clear that both in its amount and in its degree of sophistication the medical field is far ahead. Thus there is little literature in relation to which these exploratory efforts can be developed or assessed.

These limitations dictate that the present effort be more formal and procedural than is desirable. Its basic content is a clarification of questions and a development of hypothetical arguments in favor of or against proposals that are in themselves somewhat hypothetical. Some illustrative material will indicate how the more formal issues could be developed with reference to the extension of active life. Hopefully the reader will find sufficient clarity to be able to engage in his or her own revisions of the questions, criticisms of the arguments proposed, and extension of the procedures to other matters in the field of social gerontology.

Ethical analysis is primarily concerned to explore what reasons are given for choices, and particularly the reasons that are moral in tone and character. It is concerned to explore why someone might say, for example, that to deter the rate of biological aging in humans is the "right" thing to do, or is a "good" thing to do. What would count as warrants for supporting the rightness or the goodness of such activity? In a discussion of the extension of *active* life, it is quite apparent that a valuation is already implied in the stipulation of the topic, namely that "active" connotes something that is worthy, whereas "inactive" suggests something that is not of value. Thus the qualifier "active" seems to imply that there would be reasons for not considering the prolongation simply of human biological life itself as a worthy purpose. "Active" suggests certain human capacities that are either of value in themselves, or are the conditions (and thus of instrumental value) for realizing or achieving other values. Thus the principal question of this paper can be stated as follows: What reasons can be given to justify the extension of life in conditions which make possible human "activity"? That "active" and "activity" are susceptible to more refined analysis in terms of their value-laden but ambiguous weight I hope I have suggested. We will simply presume that there is sufficient clarity about the connotations to proceed to develop three different types of reasons that might be given in favor of life extension.

The three types of reasons are as follows:

1. Individual persons desire to live as long as it is possible for them to be active.
2. Society would benefit from having a larger number of individuals live longer active lives.
3. Individuals have a moral right to live as long as possible in conditions that insure activity.

In the course of the elaboration of these reasons I shall note difficulties involved in each, and also the sorts of arguments that might counter them.

A delineation of limits or perimeters to the expectancy of life that is assumed in the following parts of the paper is necessary. For purposes of this paper we will assume what are reasonable expectations with reference to the coming decades, and not speculate upon more imaginative prospects. The assumption is that persons will be able to live actively for 3 to 5 years more than has been the case in the immediate past, and with the same extent and severity of disabilities in the last few years of life that now occur. Stated differently, we are working on the assumption that persons at the ages of 78 or 80 will have the same level of vigor and function of capacities as is normal for persons at the age of 75 at the present time. As noted, this assumption seems to be a reasonable one with reference to the next decades on the basis of projections by demographers.

I. Life Extension Is Desirable to Individuals.

This reason for extending active life, like the other two reasons that will be analyzed, has imbedded in it certain ethical and practical difficulties when it is spelled out in terms of a social policy. We begin with what will be presumed to be a generally valid empirical statement: Individual persons desire to live as long as it is possible for them to be active. This empirical statement becomes one premise for a social policy. Because individuals desire to live longer, research, social policy, and relevant resources ought to be developed to extend the period of active life. Briefly, what is involved can be seen in the following form:

a. Individuals desire to extend their active lives.
b. The desires of individuals are the basis for what is good or valuable.
c. Therefore it is good or valuable to have active life extended.
d. Therefore research, policies, and resources *ought* to be developed to extend active life.

One important assumption to be noted is that the basis for determining both what is "good" to do, and what ought to be done, is the desires of individuals. What is desirable for individuals is good or valuable. Here we confront two complications worthy of note. First, persons in the history of Western ethics who have thought in these terms have had to find ways to distinguish between an "apparent" good for an individual, and a "real" good. For example, an aging person might desire to eat all the rich foods that he or she can, or might desire to engage in as much strenuous exercise as possible. To do so, however, might be only apparently good, for each of these activities might create grave threats to health. Health would be judged to be a "real" good; at least it would have a more fundamental position in an ordering of values than the pleasures of rich food or strenuous exercise. The general point to be noted is that to ground values in desires requires a process of determining which desires are more worthy of fulfillment than others, or even which are "essential" to active life, and which are optional.

The second complication is readily noted when account is taken of the social and even natural context in which desires are to be fulfilled. The words "good" or "valuable" invite the questions, "Good for whom?" and "Good for what?" Good, or value, it can be argued, is always in relation to some person, or some community, or even in relation to the natural world. What is good (fulfills the desires) of one individual might be in conflict with what is good for another individual. Prolongation of active life of a person might not be beneficial to members of that person's family, or to a community in which there are limited resources available for the fulfillment of the desires of all individuals. Indeed, prolongation might not be good for the human species as a biological class. To introduce this complication is to force recognition of the necessity of a *distributive* principle in reasoning about policy. When the desires of all cannot be fulfilled, some principles and procedures need to be introduced that help to determine how the resources available can be distributed justly or fairly among all whose desires make claims upon them.

From these two complications we see the need for more generalized principles to sort out, if not to resolve, the ambiguities that are confronted. With reference to the need to order desires, or goods, or values, some might argue that the crucial factor is power, or capacity to purchase or in other ways secure what fulfills desires. Thus, for example, an individual who desires health and has the economic means to secure health care is the person who properly has access to it, while the person without those means has no right to it. While this offends the moral sensibilities of many persons, desire plus power has usually been crucial in determining whose desires are fulfilled.

Others might argue that social custom determines not only whose desires are to be fulfilled, but what desires have priority. For example, if one lives in a society that is generally "youth oriented," advanced age itself becomes a disqualifying factor in determining whose desires shall be met. Or, if one lives in a society that has determined that high quality health care for all citizens takes priority over the desire of some to enjoy

winter vacations in Spain, ramifications for public policy follow. Others might argue that the ordering of desires, or of values, must be grounded in the ontological structure of the human. Thus on the basis of philosophical reflection about what constitutes the "truly" human, the "really" human, one can come to some ordering of values to be realized for persons. One would, in effect, determine what "goods" are really good and therefore necessary; what "goods" are not necessary, but nonetheless worthy of pursuit if resources are available; and what desires are only "apparently" good.

With reference to the need for a distributive principle (and the two complications overlap, as has already become apparent), various delineations of the concept of distributive justice would be invoked. Some would argue that justice requires that each individual has a right to fulfill his or her desires until the fulfillment infringes upon the right of others to fulfill their desires. Since, in social experience, this comes quickly, the practical task of justice is to determine the proper limits to free pursuit of individual desires. Others would argue that equals shall be treated equally, and that those who are equal to each other are those who have the same needs. "The same needs" requires further specification in the reality of social experience; some would then argue that a judgment has to be made about which human needs are more basic. Those that are basic ought to be fulfilled for all individuals. Thus, for example, what constitutes proper health care ought to be provided to all aging persons, but what constitutes desirable recreational opportunities might be secondary, or at least might be optional with reference to the desires for recreation that different individuals have. Further permutations on distributive justice can be left to the reflections of the reader.

A further difficulty in working out this first reason is seen in the multivalent or multidimensional character of certain crucial terms that are used to simplify the basic thrust. Aristotle, for example, judged that what all persons desire as an end in itself, and not as a means to any other end, is happiness. Others have used the notion of fulfillment. The extension of *active* life, as I have indicated, already suggests that extension of biological life is not an end in itself; it provides a necessary condition for the realization of other desires or values. Presumably happiness would be one of these. Both happiness and fulfillment are multivalent or multidimensional concepts when they are carefully formulated. In order to provide more specific justification for extending life in order to pursue happiness, these complications need to be taken into account. Clearly the conditions that make one individual happy are not necessarily the same as those which make another person happy. I take it that social policy is directed to providing those conditions. If the final end of a policy is to prolong the pursuit or the realization of a state of happiness, the proximate ends must be plural. Some persons will be happy if they can live their aging years in the company of the younger generations of their families; others desire greater solitude and greater distance from families. Some persons will be fulfilled if they can continue in their vocations or professions as long as they have the capacities to do so; others find happiness in the opportunity to engage in activities deferred by their preoccupation with work during their earlier lives. For some persons the extension of physical pleasures is a major element in their happiness; for others a richness of cultural life is more important.

Proposals for social policy necessarily are based upon generalizations about what significant numbers of persons desire. The limitations of resources dictate that variations in provision of conditions deemed necessary for happiness be limited. It is not unreasonable to note that a principle of utility frequently is invoked at this juncture. The social policies that ought to be pursued are those that will provide the conditions for the greatest amount of happiness for the greatest number of persons. The difficulties frequently pointed to with reference to utilitarian ethics pertain here quite aptly. The major one is that a quantification of an elusive quality—happiness—is required to provide more acceptable reasons for particular choices.

It is not my intention to make an overall judgment about the adequacy or inadequacy of the first reason for the prolongation of active life. In our culture, which has cherished as central the value of individuals, and has organized both law and social life along the principle that persons ought to have the maximum possibilities to pursue their individual desires, this reason for life extension comes almost "naturally" to mind. The complications I have suggested are in no sense novel, but the delineation of them might be of practical significance to persons who choose to develop policy primarily on the basis of this reason.

II. Society Would Benefit

The second reason noted for the extension of life is as follows: Society would benefit from having a larger number of individuals live longer, active lives. Note the predictive aspect of this: society *would* benefit. The empirical generalization involved in the first reason is no doubt more valid than is the predictive generalization

involved in this second, for its validity is more susceptible to empirical verification. This second reason is based upon prediction of social consequences, and therefore has greater uncertainty. Both reasons involve judgments about the value of certain consequences. One could at least turn the first reason into a statement that the prolongation of active life is likely to lead to greater, for example, happiness. The consequences of happiness function to support the proposal to prolong life. In the second reason judgments of the consequences are made with reference to what is good, or of value, for society. The first had its grounding in the *desires of* individuals; the second is grounded in what is "*desirable*" *for* society.

Briefly, what is involved can be seen in the following form:

a. Society would benefit from having a larger number of individuals live longer, active lives.

b. The benefits to society are the basis for what ought to be done with reference to individuals.

c. Therefore it is good to have active life of individuals extended.

d. Therefore research, policies, and resources *ought* to be developed to extend active life.

One important assumption to be noted is that the utility or instrumental value of individuals to society determines what ought to be done with reference to them. The "collective" good, or the "common" good, or the good of society is of prior value to the good of individuals. Taken in its starkest form, this reason runs counter to the maxim that persons are to be treated as ends in themselves, and not as means to other ends. To deprive the society or community of potential benefits to itself by not extending active life would be wrong.

Two complications of this second reason have been briefly noted, and now require more development. The first is that the prediction has not been established by sufficient evidence to permit it to carry the weight that it must. Consensus could be established that the extension of the active lives of certain individuals might benefit society—the care of a vigorous genius whose research or ideas contribute to the cause of health or justice in a society in some immediate or direct way would raise no question. One could with greater ease than in the case of a person of less social significance make a rough "cost/benefit" calculation that would come out on the affirmative side of the equation. The quality and quantity of benefits could be roughly adduced, because relative to the ordinary person they would be palpably greater. It is not so clear that the same sort of argument could be made for the majority of aging persons.

Another aspect of the prediction problem pertains to what society or what community a policy has in mind when it judges benefits. If one were to suggest that the most universal human group, the species *homo sapiens*, is the proper object of concern, one would have to justify the policy in terms of contributions to the survival of the species, as well as the biologically qualitative characteristics of the species that survives. To establish this would require a considerable amount of biological research, extrapolating from the known to the predictable, and then turning back from the predictable to its implications for policy.

If one were to suggest that a particular nation/state is the proper object of concern, a large number of consequences would have to be brought into consideration. The good of a nation is multidimensional or multivalent. Consequences for economic growth and stability would have to be calculated; consequences for allocation of resources, and particularly allocation between distinguishable age groups would have to be predicted. Some judgments about the social dislocations and the political effects would have to be made. (Further suggestions are unnecessary to indicate what would be involved for a nation/state.) *Pari passu*, the same process pertains to judgments about ethnic groups, families, neighborhoods, professions, friends, and so forth. The best possible factual evidences for potential consequences would have to be adduced in order to make the strongest possible case.

The second difficulty can be stated in the form of a question. What constitutes benefits for society? A historic and knotty issue comes to mind immediately. Does one think of benefits for society in terms of a concept of the common good which in effect claims that the common good is the sum of the beneficial effects of individuals pursuing their own goods and desires? Or does one think of the common good as the good of the community as a whole, in such a way that the common good requires an ordered distribution of the goods of individuals, and in some instances the elimination of certain individuals for the sake of the common good? It makes a difference whether an affirmative answer is given to the first or the second of these questions about the meaning of the common good. If one affirms that the common good is the sum of individual contributions, then whatever the extension of active life that would permit the continuation of benefits by individuals would contribute to the good of society. If, however, one affirms that the common good is the good of the whole and that it must be determined whether

that common good is being enhanced by the extension of active life, it is likely that the extension of the active life of all members of the society would not be justified.

There is a further difficulty in judging what constitutes benefits to society. In contemporary technological societies it is easy to slip into the assumption that benefits are to be judged in terms of contributions to productivity and other aspects of the economy. Persons contribute to society by their capacities to produce. Little reflection is required, however, to grasp the limitations of this notion of social benefits. Society benefits from the capacities of persons to render social services that might not make significant contributions to economic growth or economic stability. Society benefits from contributions to its cultural life, to the quality of interpersonal relationships that exist, to the richness of its symbolic and "spiritual" life. Specification of the kinds of activities that would be beneficial to society would be required if a strong argument were to be sustained. Since the benefits are not likely to be easily comparable or commensurable, the calculations and the assessments of their significance will be rather loose and more inconclusive than is desirable.

In comparing the first and second reasons for life extension the decisive significance of a basic moral choice becomes clear. The choice is between the domination of the valuation of individuals, their desires, and their freedom, on the one hand, and the domination of the valuation of societies or communities, their "common good" and their requisite restraints upon individual desires and freedom, on the other hand. An illustration of this will make the point clearer. Physicians engaged in the treatment of aging persons have what Paul Ramsey calls a "covenant relationship" with individual patients. Their discerned obligation is to enable the patient to survive in the best possible health for the longest possible time. Medical care locates the dominant value in individuals. One would be surprised to find a physician refusing to treat an aging person because his or her continuation of life would be detrimental to the survival of the species. Population geneticists and other biologists, in contrast, think of benefits in terms of survival of the species. They are more prone to consider the survival of individuals in the context of the consequences for the species as a whole. While it is possible in theory to overcome the tensions between these two primacies of valuation, in practical policy formation the tensions are not resolvable.

Practical policy proposals in the area of aging as in other areas are frequently buttressed by mixed arguments; persons will argue that both extreme positions can be properly defended and that each carries some "grain of truth." In effect, then, as the argument for a policy is developed one finds tolerable compromises, or "trade-offs" which take into account both poles. (Absence of consciousness of the use of mixed arguments, however, sometimes leads to "rationalizations" in the worst sense for impulsive or intuitive moral responses. Persons, to justify their policy preferences, occasionally argue from whichever starting point seems to give them the greatest support in particular circumstances.)

As in the discussion of the first reason, I have introduced no novel ethical considerations, but have attempted to indicate the soft points in this second reason for extending the active life.

III. Individuals Have a Right To Live as Long as Possible

The third reason for life extension invokes a very different language and a different basic concept. Individuals have a moral right to live as long as possible in conditions that insure activity. The ground reason is not the desires of individuals, nor the benefits for society. It is stated as a *right*. While there was an "empirical" premise in the argument that developed from the first reason, and a predictive empirical premise in the second, the statement of a right is not subject to the same tests of validity; it is not verifiable in the same way. The reason for life extension is not conditioned by consequences either to individuals or to society. Indeed, it is awkward on the face of it to introduce the language of instrumental values. Individuals are, in this reason, inherently valuable; simply because they are human beings they ought be treated as ends rather than as means to other ends. The major premise is clear and forthright:

a. Inherent in being a member of the human species is the right to life, which includes the right to live as long as possible.

b. Aging persons are members of the human species.

c. Therefore the conditions which permit them to extend their lives ought to be developed.

Similar arguments are made with reference to clinical decisions in medical care. For example, there are those who argue that a terminally ill patient ought to receive whatever therapy medical science and technology can provide, even if it requires "heroic" procedures, on the grounds that humans have a right to have their lives preserved. (It should be noted that no significant moral philosophers or moral theologians

argue in this way; even the most conservative Roman Catholic theologians distinguish between ordinary and extraordinary means for the prolongation of life. Some physicians, however, act as if there was an inherent right to prolongation regardless of the consequences for the "quality" of life of the patient.) There are those who argue that radically defective newborns have a right to every possible medical intervention to preserve their lives, regardless of the incapacities with which they are destined to live, simply because they are human in biological parentage.

Clearly, if the grounds for the assertion of a right can be defended, this argument is the strongest possible argument for extending the active life. The grounds for the assertion might be secular: ("There are natural rights"); or they might be religious ("Rights are God-given"). They might also be prudential: if one did not assert that individuals have a right to the extension of life, one would have grounded the value of life in the quagmire of desires or social consequences or social utility. Apart from the assertion of rights, the values of individuals or of classes of individuals like the aging, are instrumental or conditional. If they are instrumental or conditional, one is on an exceptionally slippery slope. Rights are then conferred by others who determine the value of persons or age groups, and it is more difficult to avoid great moral harm because of the vagaries of those who have power to determine who has rights.

To argue for the extension of active life from a doctrine of rights, of course, does not avoid the problem of conflicting rights, or of conflicts in the allocation of resources when persons with equal rights compete for scarce resources. Classic "triage" situations occur, for example, in which persons with equal basic human rights to life are competing for seriously limited resources for survival. To use an expression found frequently in Jewish literature on these situations, "one man's blood is not redder than another's." In the sight of God each is of equal value. It is not important to rehearse classic resolutions of such extreme situations, and the reasons for alternative ones. The most frequent resolution is that in extreme situations it is morally licit to deny resources to some in order to save others, and the others chosen to be saved are usually those who would have greatest prospects for survival or greatest utility value to the community, or both.

To extend life from 3 to 5 years does not place the human race at the present time in a "lifeboat ethic" situation, or in a triage situation. If, however, one sets the claims of various groups within the context of limited resources, and if age classifications are used to group persons, the distributive question again emerges. Those who have special interest in the rights of the aging would need to make clear their grounds for either equal treatment with other age groups, or for special preference to the aging. If all age groups in society have equal rights to resources for health and other benefits, is there a good reason why the rights of the aging should take any priority over the rights of other age groups? Those who would argue this third reason, and whose arguments would lead to preferential treatment for the aging, would have to provide persuasive answers to the question just posed.

Epilogue

Clearly my intention has not been to state and defend a position with reference to the extension of active life. I have attempted to make a relatively simple and modest clarification of the issues that must be faced in defending policies in favor of life extension. I hope this paper is quickly superseded by work that is both more learned in the literature about social gerontology and by more sophisticated ethical analysis and arguments.

Treating Aging: Restructuring the Human Condition[1]

H. Tristram Engelhardt, Jr.

We all grow older in the sense of acquiring a longer personal history. We are temporal beings extended through time. Some of us are aging also in the sense of losing vigor and capabilities as a result of diseases and injuries, as well as a result of an internal loss of power. There are, as Mr. Hayflick indicates in his paper, two important basic distinctions to be made: (1) between being old (having existed a good number of years), and being aged (being compromised in vigor and ability by having existed a good number of years), and (2) between increasing life expectancy and increasing the span of useful, vigorous life.

In considering the implications of postponing aging, of increasing life expectancy, and of increasing the lifespan it should be remembered that humans are mortal by essence: humans are contingent beings. We exist, but we could possibly not exist; and because our existence is dependent upon an indefinite number of contingencies, we will eventually die. As we consider postponing aging and postponing death, we are considering the proportions and measures for a finite life. We are balancing values and determining what values can be achieved, given human lifespans of different characters and of different scopes. To talk as if we stand on the giddy brink of immortality is to commit the sin of hubris, and is to be punished by missing the answer to the properly human question: How can the good life in its richest sense be achieved by us who are finite, mortal beings?[2]

The possibility of altering the character of aging and the prospect of postponing aging open new domains of human responsibility. In the past, the onset of aging was "natural" in the sense that it occurred without the commission or omission of human artifice. In this conference, the concern with aging indicates a new scope of human abilities and, therefore, a new scope of human responsibility. For example, large portions of the population of developed countries are now aged populations because death, although not yet aging, can be postponed. Even if the human lifespan cannot yet be increased, human life expectancy has been increased. Both the upper limit for a lifetime and the point in life when infirmity occurs have become conditions now determined (or potentially determinable) by human action. This makes us responsible for the consequences of such action.

In reflecting on the possibility of postponing aging and death, I will touch on four points: (1) the sense of the normality of aging and the concept of a "premature" death; (2) the sense in which aging can be considered a disease, or the sense in which an aged person can be healthy; (3) the ethical claims of others to have their needs addressed before investment is made in changing the character of aging; (4) the implications for the scope of human responsibility concerning the length and condition of our lives. I will attempt to sort out ways we can talk about aging, the rights of the aged, and the character of the human condition, given the potentiality, at least theoretically, for altering the condition.

I. Of Being Aged and of Dying a Premature Death

It may seem strange even to consider whether being aged is a natural state of affairs. It appears obviously to be natural; the individual simply loses vigor and abilities in the usual course of time. But the aged now constitute a proportionately larger segment of the population than ever before. This change in what had been the usual state of affairs is due in large measure to the efforts of medicine: in particular, to public hygiene

[1]I am grateful for the discussion concerning the issues in this paper, as well as the criticism of this paper, by George Agich, Daniel Callahan, Alex Capron, Joan and Eric Cassell, Maurice Kaplan, Robert Lifton, William May, Laurence McCullough, Robert Morrison, Robert Stevenson, and Robert Veatch. I am sure that they will recognize the many places where I failed to take their good advice.

[2]I have treated this point elsewhere: see The counsels of finitude, *Hastings Center Report*, 1975, *5*, 29-36.

and its impact on the mortality rates of younger age groups.[3] As a result, the aged have become a substantial segment of the population of developed countries.[4] The increase in the proportion of the aged has occurred while the extended family which supported the aged in the past has been weakened, leaving many aged persons to fend for themselves financially or to be sustained by the state.[5] The question of the aged has, as a consequence, become a political one, structured by political considerations and policies.[6] One need only consider contemporary concerns over the financial state of the Social Security system to see the impact of having large numbers of elderly in the population.[7] Again, this state of affairs is due to the contrivance of humans who labored so that life could be extended, with the result that now persons for the most part die of chronic diseases when they are old rather than dying of acute, infectious diseases when they are young. Society now finds itself burdened with unprecedented numbers of disabled and indigent old people.

The general expectation that one will survive to be aged provides a rationale for distributions of wealth from the young to the old. For example, the Social Security system rests on an expectation by the young contributor that he or she will live to be an old recipient.[8] Old age has become an everyday expectation rather than a mere hope. The talk about retirement years is phrased in terms of this expectation of growing old. Ours is a lifeworld in which new things have come to be taken for granted—living until one becomes aged, living to benefit from public programs for the aged, and so on. These expectations form the basis for a fabric of duties which bind together the young and the aged. The aged constitute a class of the once-young who contributed to a system so that when old they could be secure. The now-young benefit from the general contributions to society made earlier by the now-aged. There is a fabric, in short, of implicit obligations and expectations binding the young and the aged, one that is still working itself out into public policies with respect to the care and the position of the aged.

Such policies concerning the aged have developed in the context of a general acceptance of public health and other medical programs and policies that have themselves led to the presence of a large class of aged persons. The aged are perceived to be alive as the result of generally unproblematic policies of preventing "premature" death.[9] The implicit choice for the individual is an obvious one, as exemplified by a conversation I once overheard between two elderly men. The first remarked: "It is hell to be old," and the second rejoined, "It sure is; my father told me when I was a kid, 'Don't ever get old.' But when you consider the alternative—what the hell!" Even the compromised existence of old age appears preferable to no existence—that is, to an early death.

This very understandable attitude has caused major demographic changes. There has been a population explosion, not simply because reproductive rates have been unchecked, but because fewer children now die "prematurely." There are now, in a sense, too many children: there is inadequate food available for a large number of the children born each year, to say nothing of the inadequate resources to afford them what most persons in developed countries would consider a full life. Because we have come to value having each person live longer and live a fuller life, we have come to value having fewer children. Fecundity has thus ceased to be an unqualified natural virtue and has become something akin to a vice.

The changes that have taken place in the patterns of dying have already had striking consequences—namely, the population explosion. In fact, problems concerning the further extension of life expectancy are tied to widely pursued programs to decrease infant and childhood mortality rates. Persons are starving in underdeveloped countries because, *inter alia*, those countries are pursuing incompatible policies: insufficiently limited reproduction and increased life expectancy (especially increasing the life expectancy of children so they can live to reproductive age), at the same time that resources remain limited. Such policies lead to increased length of life without increased quality of life insofar as that quality depends upon available resources (e.g., food). On the other hand, once one has decided to

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[3]Dubos, R. *Man adapting.* New Haven: Yale University Press, 1965, pp. 229-230.

[4]Freedman, R., & Berelson, B. The human population. *Scientific American*, 1974, *231*, 31-29; Westfoff, C. F. The populations of the developed countries. *Scientific American*, 1974, *231*, 109-112.

[5]Riley, M. W., Johnson, M., & Foner, A. *Aging and society, Vol. 3, A sociology of age stratification.* New York: Russell Sage, 1972, p. 176.

[6]Phelps, H.A., & Henderson, D. *Population in it's human aspects.* New York: Appleton-Century-Crofts, 1958, p. 221; Tibbitts, C, & Donahue, W. (Eds.), *Social and psychological aspects of aging*, Vol. I, p. 55. *Proceedings of the Fifth Congress of the International Association of Gerontology: Aging Around the World*, (4 Vols.) New York: Columbia University Press, 1962.

[7]Will the Social Security bubble burst? *Nation's Business*, 1974, *62*, 28-32.

[8]Dale, E.L., Jr. The young pay for the old. *New York Times Magazine*, January 14, 1973, *8*, 40.

[9]Phelps and Henderson, *op cit.*, p. 207; Coale, A.J. The history of the human population. *Scientific American*, 1974, *231*, 41-51.

decrease reproduction and to increase life expectancy, one has implicitly committed oneself to the problem of providing a meaningful life for the aged. One has decided that a greater quality of life—living longer and consuming more resources per person—is preferable to a greater quantity of human lives.

There are special problems of defining the quality of life: of increasing enjoyable life, not life that is a burden to the persons living it. In particular, one is forced to examine the prudent limits to which life should be extended, and what sense it makes to talk about "premature" death, "premature" aging, or death too long delayed, for such questions concern the scope and bounds of human life. There is, of course, an obvious sense in which aging or death can be premature—namely, getting old or dying before other members of one's cohort. In this sense, the statistical average is normative: one decides there is no complaint if one's lot is similar to the common lot. Thus, one perceives aging due, say, to Alzheimer's disease, presenile dementia, as premature.

The sense that aging or death is premature also derives from the truncation of projects one expects to complete. A premature death is one that comes before one has done the things he wanted to do. Of course, the usually expected time of death may come after persons have done the things that make their lives worth living, making those deaths too late. This last point underscores the issues of the quality and significance of the life gained by postponing death. To say that *X* died prematurely, or aged prematurely, implies that aging or death was premature with respect to certain expectations—a blend of the usually expected scope of life and the scope of one's projects.

These comments are not meant to suggest that death is usually welcomed or should be welcomed, even if it comes at an expected age and after one's projects are completed. Instead, I am suggesting that such a death cannot be termed premature. Of course, this is somewhat circular—one is less likely to engage in projects that one knows will not be completed, given the usual scope of life. One measures projects by the length of one's life, and measures the scope of one's life by the scope of one's projects. As a result, the question of the meaning of free time or leisure time of the aged becomes central to extending the scope of human projects. If one merely extends the scope of human life without extending the scope of human projects, death may be perceived by the aged as coming too late. Or, to put it another way, death and old age are not premature if old age offers only a *taedium vitae*. Postponing death will, in short, be a contribution to the human condition only if the longer lifespan will allow for the realization of new projects, or the completion of more ambitious or extended life projects, and only if those whose life is increased believe that a shorter life would have entailed premature aging and premature death.

This brings me back to Hayflick's distinction between being old and being aged: the focus of research aimed at postponing aging should have the goal of helping us get older without becoming aged. But there is a second point: such research inadvertently turns aging into a disease process, a process to be treated and controlled by medicine. From this perspective, aging is not a process to be accepted passively as an unalterable given of human existence, as is our eventual death. Aging becomes a process open to medical explanation, prediction, and control: that is, it becomes the subject of diagnosis, prognosis, and therapy.

II. Aging as a Disease

To call aging a disease may seem to compound the confusion, for the concept of disease is itself ambiguous. Yet aging is a disease because it shares essential characteristics with other conditions that are termed diseases. Consider, for example, Talcott Parsons' description of the four essential aspects of the sick role:[10] First, being sick exempts persons from normal social responsibilities—and aging does this. Second, the sick person is not immediately responsible for his state, that is, he cannot just will it away—and that is surely the case with aging. Third, and more important, the sick person is supposed to get well—and aging research is focused on finding means for postponing and preventing aging, and rehabilitating the aged. Fourth, and for our purposes most important, the person who is sick is to seek the help of physicians and others in the health care establishment. Here is precisely where the shift in responsibility is very striking—the possibility of postponing aging makes unpostponed aging a state of illness to be treated by medicine. Unpostponed but postponing aging makes unpostponed aging a state of illness to be treated by medicine. Unpostponed but

[10]Parsons, T. Definitions of health and illness in the light of American values and social structure. In E.G. Jaco (Ed.) *Patients, physicians and illness*, Glencoe, Ill.: Free Press, 1958, pp. 165-187; Illness, therapy and the modern urban American family, pp. 234-245; The mental hospital as a type of organization, in M. Greenblatt, D.J. Levinson, & R.H. Williams (Eds.), *The patient and the mental hospital*, Glencoe, Ill.: Free Press, 1957, pp. 108-129; and *The social system*, New York: Free Press, 1951, pp. 428-479. For a summary see M. Siegler and H. Osmond, The "sick role" revisited, *Hastings Center Report*, 1973, *1*, No. 3, 41.

The term, unpostponed but postponable aging, indicates that although aging is inevitable, some postponing of aging is possible; and that aging which we decide to postpone and are able to postpone will constitute the disease of being aged. Such aging will be a disagreeable state or condition recognizable within the sick role; that is, among other things, it will be assigned to the province of medicine. As expectations of longer life expands and as the compass of human projects for life expands, unpostponed aging becomes a condition that should be pushed back indefinitely. But aging can only be postponed, not prevented, because at some time, given our contingent nature, aging and death will occur. This is to say, again, that forever is a long time, and in the long run we will all die.

The distinction between unpostponed and unpostponable aging is important in saying that an aged person is in good health, as when one might say, "He is in good health for a man of ninety." The expectations for activity are adjusted to meet the physical limitations we take to be beyond our control. Thus, the dyspnea that a 90-year-old experiences after climbing five flights of stairs might be termed normal, and that 90-year-old person is said to be in good health—even if the dyspnea would be abnormal and a sign of illness in a 20-year-old. Norms of health and disease are therefore age dependent, and one element is the expectation that the person can carry out projects and activities we come to associate with a particular age.

These norms are not purely statistical, for they also depend upon what we think *should* be the case and what we can do to alter the state of affairs. If a cure or preventive were discovered for presybopia, presybopia would become an abnormal condition, a disease, even though it is a generally occurring phenomenon. In short, diseases, even if they are the rule, are to be treated. That is, we sort out various phenomena as syndromes to be treated and controlled by medicine, whether or not they are imposed by physiological or psychological regularities. They become syndromes if (1) they thwart the goals we usually assign to persons, or (2) they cause pain that is not part of the process leading to an acceptable goal (e.g., "normal" pain after "normal" exercise is not pathological, for it is seen as part of the process of keeping physically fit), or (3) they constitute a deformity (an esthetic criterion—certain changes associated with aging can be regarded as ugly and are therefore to be treated by medicine even if all aged persons are so afflicted).

Whether or not the pains and disabilities of aging are considered diseases depends upon our judgments and our expectations concerning the human condition. Consider, for example, the argument that menopause is a disease: "We believe the menopause and the menopausal state to be a disease so insidiously blended with chronologic aging that there is a tendency for it to be overlooked and neglected."[11] This assertion is complex. First, it is held that "a menopausal woman is . . . not normal; she suffers from a deficiency disease with serious sequelae and needs treatment." Second, there is an implication that aging is normal and therefore not a disease. Third, there is the implication that we can and should treat this state of affairs. It is exactly with regard to the second judgment that aging research is likely to expand our concept of "disease" to include the general disabilities and pains of old age. We are likely to see the events of aging, such as menopause, placed under the rubric of disease as we come to be able to control them.[12]

In short, there are no definitive answers: norms for what will count as nonpremature aging, and norms regarding the meaning of health for the aged will depend on our ability to alter the processes of aging and on our decisions concerning the life projects that should be open to humans.

III. Claims and Counterclaims

Since resources are limited, there is the problem of choice between preventing diseases of the young or postponing aging, or between feeding the hungry of other countries or supporting our desire to give longer life to our own people. Such questions obviously have no easy answers. Moreover, the questions multiply. What projects should receive research investment—childhood leukemia or aging? Such questions concern fairness or justice within a particular society, and they can be translated like this: Should not everyone be given a fairly equal life expectancy before we expand the life expectancy of some? Do not those who would otherwise die young have a moral claim to be helped to live a statistically average life? And should this not be provided before resources are expended to increase general life expectancy? In Dr. Goddard's paper this issue is put in more universal terms, whether a society must solve its existing ills before taking an action which

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[11]Wilson, R.A., Brevetti, R.E., & Wilson, T.A. Specific procedures for the elimination of the menopause. *Western Journal of Surgery, Obstetrics, and Gynecology*, 1963, *71*, 110. Kirstner, R.W. The menopause. *Clinical Obstetrics and Gynecology*, 1973, *16*, 106-129.

[12]For a treatment of some of these issues see H. Tristram Engelhardt, Jr., The concepts of health and disease. *Evaluation and explanation in the biomedical sciences*, Vol. 1, Dordrecht, Holland: D. Reidel, 1975, pp. 125-141.

could produce new problems, such as the problems that will occur as a consequence of delaying aging or death.

To the person who will die young because money has gone to aging research instead of to other disease research, there are a number of possible replies. First, it might be argued that investment in aging research is justifiable as long as the same amount of resources is invested to help those who would otherwise die young. Also, proportions of research resources can be established that are not problematic. Dr. Goddard supplies a partial answer by pointing out how little, relatively, is presently being invested in research concerning aging.

Second, as long as those who die young die of diseases that are randomly distributed in the population, and given certain low incidences of diseases which entail early death, it can be argued that one can take one's chances with disease. We should invest resources in expanding the scope of useful life because one's chances of being benefited would be best under the latter arrangements. The answer could, in short, be made within a cost benefit analysis without affronting considerations of duty. Pursuing research on aging would not be unjust to those rare persons who die young.

The issue would be different if the incidence of such diseases was itself due to unjust social practices. Afflicted persons could then hold that they had been dealt with unfairly, that the gamble had been rigged. But as long as the distribution of illnesses is not due to social injustice, the use of public resources for research on aging is not more problematic than funding the National Park Service.

In short, health and a long life are not absolute goods. Rather, they are instrumental goods. One must be in good health in order to enjoy good food, art, nature, sex, sports, and philosophy. That is not to say that life choices are not problematic. They involve the issues of choosing a human life which has a proper balance between goods, a life that will be worthwhile, even beautiful. To choose to fund the National Endowment for the Arts, rather than to build better highways, is to assert that it is better to run the risk of accidents on poorly constructed highways than to have a culture in which it is not worth surviving. This should remind us that postponing death is worthwhile only if the extra life justifies the trouble.

The duties among societies is a difficult issue, even after it is granted that all humans are in some sense a single community, a community within which certain general claims of distributive justice can arise. To give priority to the claims of impoverished nations, such as India, for food and assistance before extending our own life expectancy—this would be a reformulation, in a broader context, of the claim to a fair share of the opportunity for long life. That is, such societies could be seen as claiming a right to life expectancy equal to our own before we further increase our own life expectancy. These claims can, to a certain extent, be refuted. As long as such societies fail to make provision for adequate birth control, their request would lead only to greater injury to more persons, and to the creation of further disadvantage to individuals who will be born. To provide food and medical care so that more people can live and reproduce, and to cause even more persons to live under exigent circumstances, is surely not a moral duty. Quite the converse. To increase the number of suffering people is not morally justifiable. Moreover, there is no duty to allow potential persons to come into existence if it would materially disadvantage present persons (given that there is no overriding value at stake such as continuing the species). One can injure persons by creating more persons. In short, the alternative may be more problematic than to invest in aging research.

When starving societies make provision for adequate birth control, they will have actively joined us in the enterprise of changing mortality and morbidity rates, of restructuring the human condition in order to increase the general quality of life. Such a choice is, in many respects, similar to the decision to increase life expectancy by altering the aging process: it involves increasing life expectancy (and quality of life) by decreasing the number of humans who would otherwise be born. Once these choices are embraced by such societies, the argument can then be made that our assistance in support for population control, and for improvement in the general quality of life, should take precedence over any major efforts on our part to increase our own life expectancy.[13]

These issues are complex, furthermore, because members of a society may be willing to work harder (or contribute tax dollars) so that they themselves can live longer, but not for other people to live as long as themselves. In short, the lines between duty and supererogation are difficult to draw, and it is difficult to determine

[13]I do not wish to suggest that sorting out the moral issues involved here is easy. A good argument for moral duties to aid other countries is given by P. Singer. Famine, affluence, and mortality. *Philosophy and public affairs*, 1972, *1*, 229-243. Further, I am not arguing for a "lifeboat ethics," as proposed by Garrett Hardin, Living on a lifeboat, *Bioscience*, 1974, *24*, 561-568. I am presuming, however, that individuals achieve the good life in and through their societies, and that one is not duty bound to help individuals if their society thwarts the success of such efforts.

what wealth is surplus and what amounts can be expended capriciously without regard to the suffering of others. The liberty to pursue one's own selfish good may, within certain limits, turn out to redound to the greater good of all, even to the least advantaged. Moreover, there are surely issues at stake in coercing anyone to work for the good of another, even if in some sense he *ought* to work for the good of the other.

Finally, Dr. Goddard and Mr. Hayflick suggest that attempts to decrease the loss of vigor associated with growing old could prevent more suffering than short-range efforts to prevent disease. Just as it was more beneficial to do research on polio than to provide better iron lungs, it might be better to do research on aging than to attend to the claims of the present aged. These are, once more, issues of balancing the claims of the young versus the aged. On the one hand, members of a society have *prima facie* claims to equal access to common resources, and the present aged can not be abandoned in order to benefit the present young when *they* will become old. On the other hand, projects that have general public appeal (such as the postponement of aging) can, with common consent, become a goal in which national resources are to be invested. If the present aged are not abandoned, then resources can properly be invested to benefit the future aged.

The criteria for such decisions can never be clear-cut. Given certain basic abstract restrictions—e.g., never treating persons merely as means—a society can properly decide on its configuration of values in much the same way that an abstract painter chooses his colors. There are many ways to achieve the beautiful, although they involve proportions which are difficult to specify. But some specification of the proportions are needed to avoid both immoral and tragic outcomes. Warnings such as Hayflick's that "most gerontological sociologists are persuaded that even as little as a 5-year increase in life expectancy would be so profound as to rupture our present economic, medical, and welfare institutions" are warnings that we must analyze the values we wish to achieve, and that we must determine the conditions under which they can be achieved.

IV. Aging, Death, and Human Responsibility

An examination of the issues associated with postponing aging and death should not overlook the fact that such postponement invites the question of when death *should* come. The fact that death can be postponed, not simply embraced early, as by suicide, reiterates in a more pressing fashion the question raised in ancient times with respect to the proper time to end one's life.[14] The question arises particularly when postponing death leads only to prolonging the aged state. That is, a general set of circumstances may arise when many individuals will find the better choice to lie in euthanasia rather than in an old age of great debility. Hume's remarks concerning suicide are appropriate here. Man's moral obligation is to act rationally and there are at times good grounds to end one's life. There is, as Hume argued, a continuum of human responsibility which is acknowledged as soon as man begins to change nature in order to meet human goals.[15] Whether extending or ending life, this responsibility is of one fabric with general human responsibility for choosing rationally the conditions of life. Choosing to increase life expectancy involves the choice of how long one should live and when one should die.

Dr. Goddard appears to believe that the issue of euthanasia is avoidable if longer life depends upon the effort of each individual (i.e., individuals could cease to prolong their lives). This position presupposes that there is a moral difference between acting and refraining,[16] between refusing to lengthen one's life and deciding to end it at some point. But even if one grants that there is a moral difference between acting and refraining (e.g., that *acting* to kill oneself involves a morally impermissible violence against oneself), both would involve a choice for which one would be responsible. As soon as one can postpone aging or death, early aging or early death is one's own responsibility, even if that aging or death occurs only by omission.

Technology increases human responsibility by opening new possibilities and thus making it possible to make new morally significant omissions. For example, Mr. Hayflick suggests that, once the means are available, persons will neglect to use the means of increasing their life expectancy, just as parents now neglect to have their children immunized against polio. Even though most parents who neglect to immunize their children do not intend that their children become ill, those parents are, all else being equal, as morally responsible for the consequences as they would be if they deliberately exposed their children to polio. Similarly, with respect to euthanasia, the issue is not that of compulsory euthanasia, but the fact that through omission or commision one is now responsible for the scope of

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[14]Seneca, Letter LXX: Suicide.

[15]Hume, D. Of suicide. *Essays, moral, political, and literary*, Vol. 4 of David Hume, *The philosophical works*. T.H. Green and T.H. Grose (Eds.). Aalen, Germany: Scientia Verlag Aalen, 1964, pp. 406-414.

[16]Bennet, J. Whatever the consequences. In J. Rachels (Ed.), *Moral problems*. New York: Harper & Row, 1971, pp. 43-66.

one's life. The decision whether death comes too late or too early becomes unavoidable, given the ability to extend human life, and given that the life extended may, at times, not be worth the difficulties to the person whose life it is. In short, the technology of extending life confronts the individual with the decision of when he or she has had enough. Such decisions have always been at hand, but the ability now to intervene more effectively in the "natural course of things" makes human responsibility much more explicit by increasing the choices.

In conclusion, we are, as Dr. Goddard indicates, faced with a national goal which could transmogrify our society. But, as has also been pointed out, we embarked on the project of the prolongation of life when we decided to decrease infant mortality rates. As a result, we have already begun to face the issues which further extension of life expectancy will raise: the value of children, the use of leisure time, the care of the aged. We need to recognize that we have already embarked on this project, this national goal, and that we must proceed with care, for the project involves us in analyzing the place and role of basic values in human life. Moreover, it is important to recognize that health and disease involve value judgments which structure our attitudes and actions with regard to aging and the aged. In short, considering the prolongation of life should make us clearer about the choices and presuppositions that underlie our understanding of the human condition. In particular, proposed research on ways of controlling aging will press us further to cease viewing the human condition as imposed by nature, and to recognize that the human condition is fashioned by humans in terms of particular goals and values.

The Aging Society and the Promise of Human Life

Warner A. Wick

Presuming that it serves a function to provide a "keynote" for this Conference, I propose to take that underlying musical metaphor seriously. A keynote may not be where a piece of music starts; but it must be the "home" note, determining the chord that ties everything together at the end. A number of themes may be stated, followed through a variety of developments, inversions, oppositions, and unstable balances; but they all implicitly point toward a concord we recognize when it comes, because it resolves the tensions and brings the elements into focus. Thus the keynote sets limiting conditions without dictating the content of the music or how it reaches its goal. That, at any rate, is how I conceive my role: to indicate a principle of unity we ought to observe in organizing the problems at hand, for judging the relevance of what we say, and for measuring our success or failure in finding an orderly resolution of our principal themes.

This Conference faces one of the most consequential demographic facts to have affected the quality of human life on earth. No matter what any of us may do, it is practically certain that the balance of young and old will soon be profoundly different from anything with which human society has had any experience. Without experience of a world in which any more than one person in 30 or 40 is past 65, we have nevertheless been trying to cope with a newly changed world. The one-in-twenty ratio, which was achieved in this country about 50 years ago and led to the establishment of the Social Security system a decade later, has been handled only haltingly, by measures aimed at the most obvious points of strain. We have not come to terms with its indirect effects on our culture and consciousness; and such continuing stresses are a principal reason for conferences like this one. But in the meanwhile we have passed the one-in-ten point and are rushing ahead into unknown territory at a pace accelerated by the recent unexpected drop in the birth rate. As Dr. Hayflick observed in his paper, "It is not too difficult to imagine a society in which the major efforts of those under 65 will be directed toward the care of those over 65." A "presbyterian" society of workers and ruling elders, we might call it, remembering that such an order of governance was what the word "presbyterian" was coined to designate.

"Experience keeps a dear school," says the proverb, "but fools can learn in no other." The proverb, of course, comments on individuals who could not or would not learn from the funded experience and advice of their predecessors, but only from the school of hard knocks. Our problem with the aging society is of an altogether different sort, for there are no men of experience and wisdom to advise us about its eventualities. We must anticipate the hard knocks and avoid them if we can. Even so, a first formulation of our problem is to ask how the present generation can avoid being judged foolish by the tribunal of history—indeed wantonly and irresponsibly foolish—if it should turn out that we had plenty of evidence about the consequences of the course we are pursuing, but that we ignored that evidence.

While the aging society is a fact, and must be dealt with as such, Dr. Goddard, playing Mephistopheles, is tempting us with a possibility: not, to be sure, the possibility of everlasting life, but of life indefinitely extended. He invites us to consider investing in it as in a national goal, much as we invested in the eradication of polio or in the technology for going to the moon. He suggests that it may be no more expensive in current resources than the latter venture. But what a difference in the pay-off! For those of our fellow citizens who have felt that they got little from their moonshot dollars except some good evening television shows, their elevation to a station scarely below the immortals would be. . . .? I am afraid that words fail. We do not know, and we can not imagine, what is being offered. It is like wondering how we would spend our time in heaven, although I don't suppose many people do that kind of wondering any more.

I am glad that Dr. Goddard has made his modest proposal, for it opens up the primary question before us—really a complex of related questions united around a keynote. The keynote question was already

implied by the phrase, the aging society, but the keynote question is broader. It does not merely determine the reference points of this conference. Although I feel some diffidence about using language that has been cheapened by so many self-elected prophets, I should say that the keynote question poses the ultimate problem of men of any era. Briefly it is, What are we, and what is our place in the scheme of things?

Of course the question, so phrased, is unmanageably ambiguous. Any question presupposes unstated understandings that are themselves the conditions if the question is to make sense. "What is the best road to Kokomo?" presupposes that there is such a place, that it is within traveling distance, and that the questioner has some interest in what is happening there.

Until recently our keynote question would have presumed that its object, man living in society, is something "given," circumscribed within limits capable of being discovered, and expressible in such terms as these: that mankind is a species having a constant "nature;" that man is a creature living within certain bounds set for him by "nature" in a somewhat different sense of the word; that he comes from dust—or protoplasm—to which he returns after a brief excursion whose nobility or shamefulness does not depend on how long it lasts; that he is dependent on the economy of the earth and its fruits; that he is also dependent on other men and the security of whatever order in society he and his fellows can maintain. And so on. Conceived in this way, the problem seems to be mainly one of knowledge, of scientific knowledge if you like. We can learn to "know ourselves" in one of the possible meanings of the famous oracle at Delphi; and having done so we will have learned the range of possibilities that set the limits of our freedom.

But by this time we can see that the keynote question, formulated in the same language, has acquired other presuppositions that change its meaning radically. We can no longer assume that what we are, and our place in the world, are simply given and waiting to be discovered and understood; for we know that both have been changing and may change still more, whether or not it is our deliberate intention to change them. We have become aware, for instance, that we now can—and indeed may—make the earth uninhabitable for the plankton of the oceans that are the foundation of the food chain, and therefore also make the world unlivable for us. We can do this if, beforehand, we have not inadvertantly eliminated ourselves from the scene through some less roundabout agency. Some by-product or "fall-out" from the pursuit of any of several national goals might do the trick. That we have become actually *responsible* for the future of the earth as a possible dwelling place is a disturbing truth, even though it is far from being generally "known" as a shared possession of human consciousness. So much, for present purposes, for "our place," understood as our theater of operations.

As for ourselves, in the sense of our nature as a species, it has been clear since Darwin's time that we can, and do, affect the workings of "natural" selection and in doing so, we affect the distribution of genetically determined human qualities. How many millions who would have died of some genetic fault have we saved for "useful lives"? And also for opportunities to increase and multiply their defects, both directly and by contributing recessive genes to circulate, like time bombs, in the common gene pool? Such eugenic concerns, much discussed a century ago, are seldom objects of public attention these days. Perhaps they have been put in that closet of our minds reserved for items that are too embarrassingly touchy. And it is easy to reassure ourselves by saying, often with justification, that the disagreeable manifestations of genetic defects can be controlled by hormones, drugs, surgical refabrication, and perhaps even by replacing defective organs by spare parts, either manufactured or recovered from "neomorts."

However that may be, eugenic devices for breeding changes in the distribution of human qualities work so slowly that their neglect is not surprising, especially in view of the practical and political difficulties of managing them. In contrast, the revolution in molecular biology provides techniques for direct intervention that make it unnecessary to wait for the tedious processes of selective breeding. A number of genetic diseases such as Mongolism and cystic fibrosis can be detected in the unborn fetus, which can then be aborted. With systematic screening in early pregnancy, the frequency of such disasters and their threat to future generations can be reduced very quickly. A more spectacular stratagem, still on the drawing boards so far as humans are concerned, but demonstrated on some lower species, is cloning. It works by grafting a cell nucleus from a selected donor into an egg cell, which then develops as if fertilized and produces an exact genetic replica of its single "parent." Imagine the mass replication of baby Albert Einsteins! Or Marilyn Monroes? The upshot of these brief observations is that we are in a position to redesign the human species to at least a statistically significant extent, and even to engineer the production of models to order. Devices as yet unknown for extending the cell's lifespan, but which would owe their eventual practicability to Dr. Hayflick's fundamental research in cytogerontology, would be similar in

that they would operate upon the basic regulatory mechanisms of life and reproduction.[1]

So there is a second way in which we have acquired unaccustomed responsibilities of awesome proportions. We have become not only custodians of the earth but agents in the processes of creation; and among the species for whose capacities and defects we share responsibility is our own. We can not regard ourselves simply as creatures any more, having become self-conscious participants in the ways of Providence: demigods, one might say.

My use of the word 'god' here, even in lower case and hyphenated form, has been neither frivolous nor designed to irritate the hard-shelled rationalists. It has been partly to establish a perspective for judging the warnings against "playing God" that usually turn up when measures affecting life and death are discussed. I hope it is evident that we are already deeply into the Providential role and we can not get out of it. For to forebear from doing what one can, when the stakes are high, is as much an exercise of power as to act; and to "let nature take its course," when we can intervene, is not to evade accountability for the outcome.

All this is to remind us that this kind of responsibility for ourselves is not entirely unfamiliar in kind, however unprecedented it may be in extent. It has been characteristic of human culture, ever since our first efforts in self-interpretation, to acknowledge that man has a modest share in the attributes and prerogatives of divinity. According to the story of Genesis, for example, Adam and Eve at first enjoyed the innocent irresponsibility of dependent creatures whose every need was provided for, so long as they accepted the terms of their good fortune. But as a result of Eve's curiosity about "the fruit of that forbidden tree" of knowledge, they were elevated to another plane as knowing agents of good and evil, becoming "as one of us," as Yahweh is reported to have complained. It was, as we say, a whole new ball game. But as usually happens, a promotion in rank brings new headaches along with it. Knowledge is indeed power, as Francis Bacon taught a receptive world when the age of modern science was beginning; but the companion truth, that knowledgeable power is responsibility, is one whose implications we have been more reluctant to face, let alone to explore.

[1]For a general presentation of the opportunities and issues of such biomedical engineering, I recommend the articles in *Science* by Dr. Leon R. Kass, then Executive Secretary of the Committee on the Life Sciences and Social Policy of the National Research Council, National Academy of Sciences, a series of papers which appeared in *Science* in 1970-71.

Having sketched how our keynote question—What are we, and what is our place in the scheme of things?—has changed in meaning as its presuppositions have changed, I now ask you to join me in reflecting upon the significance of this transformation of the question. The first thing to observe is that it is no longer simply a question of "knowledge" in the usual scientific sense; for this presumes that the object of inquiry is independent of us and our activities, and that our task is to pursue the truth by bringing our ideas into conformity with the object. The paradigm of such knowledge is celestial mechanics: the planetary motions were simply "there" to be accurately described by Kepler's laws and to be explained by Newton as the effects of universal gravitation. But with the question now transformed, so is the relation of knowledge to its object also transformed. It is not a question of discovering and explaining an "objective" situation, nor is the difficulty primarily one of adjusting to a moving target rather than a stationary one. Instead, the changes in what we seek to know about are the effects of what we know about it, and vice versa—in a continuous process of reciprocal interaction.

The second point to observe is that the problem, thus transformed, is of a kind that is by no means unfamiliar in everyday life, although it is one that our habitual canons of scientific thought find troublesome. All understanding of human behavior and institutions is of this sort; for when we think we know why there are ups and downs in the business cycle we immediately do something to affect them, guided as we go by our conception of the causes we have discovered.

Now it is of the first importance that we keep in mind two essential components of this "practical" use of knowledge. On the one hand, what we set out to do often turns out differently from what we intended, and even when we achieve our intended objectives the unforeseen fallouts of success may be appalling. On the other hand, the point of investigating the causes of the business cycle, and of social phenomena generally, is that we do so *in order* to change their operation, and change them we do, for good or ill—a project that would make no sense if we were investigating the behavior of the solar system. Viewed more generally, human culture has always been at once self-transforming, aware that it is, and—when it has been most thoughtful about itself—aware that only some of the determining variables of change can be brought under explicit control at any one time.

In sum, because man, the animal with a culture, is constituted by his socio-cultural as well as by his biological inheritance, inquiry about human society modifies its object, modifies itself, and modifies man at

the same time in ways that can be only partially foreseen. It is therefore "no accident" that chance intrudes itself into our best laid plans, and that we are more vulnerable to it the more self-confident and single-minded we are in pursuing our various limited objectives. That is the lesson taught by the tragic dramatists. What is new in the world is not man's self-transformation through the use of an understanding which is clearest about its ends when those ends are limited in scope. What is new is the encompassing of more and more of the "natural" conditions of life under the hegemony of that imperfectly reflexive, feedback process.

Combining these points that, in being responsible for our cultural and biological existence, what we know and fail to know about the human condition also affects it, and that whatever we do to ease man's estate reflects our partial understanding of it, we must conclude that to ask what we are is at the same time to ask what we are to become. However, this is not a request for a prediction, as if we could stand outside our subject matter as we do when calculating the time of a solar eclipse. It is rather to engage in deliberation about deciding a line of policy—a course of action subject to continuous revision. And so, finally, our keynote question asks what we *ought* to make of ourselves and our place in the world. It is not that "the is and the ought" are not distinguishable in thinking about action, for when they are taken abstractly they are clearly distinct. The point is rather that they can not be made use of in a reasonable way except in their mutual relations. That is to say that *not* to reflect on what makes life better or worse while investigating what makes it longer or shorter is simply irrational.

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At this point I think that my job in this conference is almost done. That is, I have tried to clarify the general sort of question through which the specific subquestions of this conference can be brought into relation to each other, but without prejudging any of them or interfering where others can speak more pointedly than I. I assure you that I find only cold comfort in the highly general but humbling conclusion that mankind, having become responsible for its future to a hitherto unimagined and still undercomprehended degree, is stuck with it; that our success in achieving well-defined short-term goals—such as acquiring the know-how for extending the life span—is accompanied by an awesome and perhaps tragic incapacity to comprehend "what we are doing" from the standpoint of determining the future quality of human life; and that probably the best we can do is to try to relate our current choices to a reflectively weighed discussion of the old questions about what constitutes a good life in a good society. I know of no technical rules for bridging the gulf between such a comprehensive ideal and the immediate issues of policy. But I can indicate a few lines of connection that may provide food for thought.

In thinking about the aging society, necessity as well as good will demand that we seek better ways to provide for the support of the unprecedented number of old people among us and for their disproportionate health needs. Surely justice and humanity concur in endorsing those goals. With regard to extending the life span, the value, if not the immediate necessity of understanding the biology of the aging process seems to be beyond question. Whether it may be desirable to *use* that understanding in order to extend the limits of life—as opposed to increasing its average length by delaying and shortening the period of deterioration by reducing the incidence of disease—is a further question. Presumably its answer should wait for information about how, and at what stage in life, the aging process can best be controlled. But despite these obvious values, each policy goal is subject to questions of the utmost gravity. The paradox that the pursuit of a number of patently obvious goods may not be good on the whole, this paradox is something I have tried to prepare for in a general way in the first part of these remarks. It remains to suggest some specific connections.

With respect to any set of policy questions, it is always relevant to ask, "To what end?" until one reaches a comprehensive end to which all the rest contribute. It is natural to describe such an end as a world, or at least a human society, ordered by justice and enriched by welfare; and for many purposes it is convenient to think of this end in largely quantitative terms: more desirable things for more people, and all fairly distributed. But when we reach fundamentals, this notion of welfare itself comes into question.

Let me illustrate by referring to the economic problem of care for the aged. When we ask how we are to provide for those who are unable to work and earn or who are not allowed to, we should notice what is taken for granted by the way we ask the question. It assumes the whole complex of the job-conscious industrial society, in which young and old alike have been progressively excluded from the privileges of what is called productive work. A first consequence of this is that the entire burden of providing for youth and age rests upon those who enjoy the possession of a job, and that various custodial agencies become necessary for the excluded classes. Custodial care is expensive, whether it takes the form of "education" or a "Golden

Years Club" (except that these are also "good" because they "create jobs"). A second consequence is that, since one's job is a principal source of a sense of identity and self-respect (as can be seen in the morale problems of the unemployed and the complaints of the women's liberation movement that housewives have no standing because their labors are "for nothing") both young and old suffer from alienation and aimlessness. So the problem of "supporting" both excluded groups comprises much more than economics and the distribution of the GNP. It is indeed a problem of welfare, but in the qualitative sense of the value of living well in a healthy community.

If two major classes of society are excluded from the sources of both self-respect and rewarding activity of which one can be proud, we can expect disorder and disaffection among the idle, as well as dismay and resentment among those who work with such determination to enforce and provide for their idleness. Of course we cannot redesign all the aspects of society at once, but if I am allowed a little oversimplification to make a point, an observer from another planet might conclude that we make things unnecessarily hard for ourselves by excluding significant aspects of a problem from consideration in the very process of formulating the problem.

Indeed, if welfare means living well, and if to live well in a peculiarly human sense is to be active in the use of one's powers in a community of shared activities, the welfare of the old is primarily a problem of their opportunities for meaningful occupations—which need not be work for pay. In that sense, and without having to make invidious judgments about what particular ways of living are best, it would appear that a peasant culture often does better by its old folks than we do.

Provide opportunities for meaningfully shared activities as we may, there are many people who become completely dependent on care for their physical needs and who face the threat of being put away in maintenance homes where the care that is needed will be poor. Like prideful janitor service, good maintenance care can rarely be bought at any price and our culture does not freely reinforce its performance.

This is not an occasion for preaching, but I think there may be some point in recalling Thomas Hobbes's classic description of that state where "the life of man is solitary, poor, nasty, brutish, and short." In up-to-date language, I suppose the first four adjectives would be "isolated, deprived, alienated and dehumanized." They seem to apply to all too many who have been put away. For them I would hope we could also add the word "short," as Hobbes had it. But I am sure we sometimes commit the ultimate barbarism by making it "long" instead.

I should like to close these remarks with a few aimed directly at Dr. Goddard's proposal. I hope he will excuse me for thinking that this sort of "national goal" is exactly what we do not need, and if he has followed my line of reasoning through this essay he will understand why. The pursuit of narrowly defined practical objectives, however Promethean, without reflection about their probable but unintended consequences is a principal source of our difficulties. And the more mind-blowing the project, the less basis we have for assessing what it may let us in for. On the other hand, I heartily advocate the balanced support of basic research in all the sciences, for I believe that the life of scientific inquiry is one of the primary expressions of human powers and therefore of living well, and even nobly.

Eventually I should expect basic research to lead to an understanding of the workings of the "biological clock." If and when it does, we shall have to decide how to use that understanding, and I should expect that there would be many possibilities. But to make it possible to live indefinitely? To what end? As I read history, I have not been persuaded that our civilization has succeeded in making better use of man's allotted years than a number of other civilizations have done.

Plato attributes to Pindar a story about Aesculapius, the demi-god credited with founding the art of medicine. Although his guild refused to practice the later system, which invented "the lingering death," the founder is said to have once accepted a bribe to stretch out the life of a rich man who was at the point of dying. In consequence Aesculapius was struck by lightning. That was a Draconian measure, no doubt, but I think there is much to be said for the view that life, simply as such, is not necessarily worth preserving.

Discussion

Robert J. Havighurst, Chairman

Havighurst: We will divide the discussion into two parts, the first part dealing with the technical problem of how to prolong life; the second part, the ethical issues involved in the prolongation of life.

The Goddard, Hayflick, and Havighurst/Sacher papers were all making the point that there are two quite different ways of prolonging life, and that they require different kinds of research. One of the big policy questions, assuming we want to prolong life, is which kind of research to support.

Goddard: I am somewhat hesitant to say anything on this subject after what Professor Wick said happened to Aesculapius for promising to extend the life of one individual. When we begin seriously to propose the extension of life for mankind, the resulting concomitants might not be acceptable.

We should keep in mind the major distinctions involved between extending life through altering what Mr. Hayflick calls the "biological clock," or on the other hand, by extending life by eliminating certain chronic diseases—cancer, coronary heart disease, arteriosclerosis, and so on.

In the first instance we are talking about changing the calendar of a person's life so that the various segments are altered, Middle age might extend from age 40 through age 70, the young-old from 70–90, and the old-old from 90–110. That is the concept of extension of life, whether or not it is based on a biological technique, or on providing an extraneous agent that must be taken as a medication every day, or on a one-time surgical procedure. The end result would be the extension of the various segments of life.

The other approach, the more conventional approach, the one we have been involved in for a number of years, is to alter the survival curve so that more people survive to be 70 or 80 by eliminating disease. In this approach, the survival curve is not only squared off and more people live to an older age, but the maximum average age at death might be increased slightly by changing the prevalence and incidence of certain disease conditions.

Both these approaches should be considered. My interest centers on the first approach, that of developing, through research programs of rather substantial scale, means of altering the basic biological calendar that is inherent and programed in the cells of our body—so that we would live on the average, say, 110 years of age rather than 70 or 80. It is a much more intriguing concept, and one that has far different implications for our society than the mere extension of life by 2 or 3 years through the conventional methods that we are now using.

Hayflick: I have been fascinated listening to the sociologists and economists and ethicists discuss what seems to me to be a purely biological phenomenon, but without getting into the biology of the situation at all. I would therefore like to take a few minutes to give some insight into some of the biological considerations which bear heavily on the issues before us.

For example, it might be observed that man may, in fact, be unique in respect to having a substantial number of very elderly members of the species present. From a quantitative standpoint, the degree of aging is far greater in the human species than in any other species (except the animals man chooses to protect, like his domestic and zoo animals).

It seems reasonable to argue that aging, as we understand it in its extreme condition as seen in man, is essentially an *artifact* of nature. Aging has been revealed only because of man's ability to manipulate his environment to such an extent that he can control his predators and his diseases to the point that individual members of the species survive. This reveals age changes that, teleologically perhaps, were never intended for man to see in the first place.

I would like to comment on the changes that have taken place in life expectation, which I think most of you are familiar with, but I will restate them in a more precise way.

We all appreciate that life expectancy at birth in 1900 was 49 years and in 1950 it was 68 years, a net gain of about 19 years. But since 1950 the gain has been only 2.4 years, and in the past few years there has been really no gain at all. The question is, why was there such a profound increase in life expectation in the first half of the century, and then an equally profound leveling off? And this, despite the fact that most of the major advances in medicine took place in the years subsequent to 1950—that is, in our ability to deal with infectious diseases, which is the prime reason for the increase in life expectation.

I would also like to make a point in respect to distinguishing between life expectation and life span. Life span, at least for man, as far as we know, has remained essentially unchanged. The same is reasonably true for most animal species. If we argue that the mean maximum life span is about 90 or 100 years for man, then the apparent fact is that this has remained unchanged. What *has* changed is that more people have been able to live longer and reach this mean maximum life span. Thus life expectation has increased, but life span has not. You often hear it said that people are living longer. They are living longer in the sense of life expectation, but the life span remains fixed. That distinction is essential in discussing what is likely to happen in the future.

In any consideration of increasing life expectancy one must look at the major causes of death, which in this country are, first, cardiovascular disease and stroke, and second, cancer. It might come as a surprise that to resolve cancer by some miracle tomorrow morning would only result in a little more than 2 years' increase of life expectation. If heart disease and stroke were resolved by some miracle tomorrow morning, however, it would result in about a 15- or 16-year increase in life expectation. The sum total is equivalent to the increase in life expectation that has occurred between 1900 and 1950.

The current orientation of biomedical research in this country and in the world is directed toward rectangularizing the survival curves, simply making it possible for more people to survive to the mean maximum life span of 90 years. The upshot of this is rather interesting, and I stated it in a facetious way in my paper, in saying that if we were successful in curing all of the diseases and ills and man, the result would be that all of us would nevertheless drop dead on the eve of our 90th birthday. The reason is that very little attention has been paid to the basic biology of aging—that is, the physiological decrements that occur as a function of time. The likelihood of lengthening the life span itself is very slim indeed, because the number of dollars being spent and, in fact, the number of people worrying about it are so infinitesimal that the likelihood of success in this latter area is virtually impossible.

So to restate it: there really are two ways to think about increasing the length of human life. One is to cure all the diseases that we are now prone to, which would result only in an increase of about 20 additional years of *life expectation.* The other, obviously, is to deal with the *lifespan*, and this is a very serious and important question that has not at all been dealt with effectively.

One does not ask cancer biologists what are the goals of their research, because it would be a stupid question. But it is not a stupid question to ask gerontologists what are the goals of *their* research, for the simple reason that the results of increasing human life expectation, or of tampering with the biological clock and increasing the lifespan, will result in social and economic discontinuities of the kind that we are already unable to deal with, even with our current life expectation. To increase the human lifespan or life expectation by even a few years would result in furthering the dislocations and the problems we have been addressing here.

Thus this is a very important question that we biologists would like to have answers to, and we need to interact with our colleagues in the social sciences before we set our particular goals.

There is one tantalizing point in thinking about our goals. There is one way in which most biologists believe we can extend our life expectation and possibly our lifespan, and this is based on work done in the 1930's by Clive McCay, in which caloric restriction—that is, underfeeding animals to the extent that they received very little in the way of calories but all they needed in the way of vitamins and so on to maintain good health—resulted in up to a 50 or even 100 percent increase in life expectation. This type of life lengthening has been seen in many other animals, and there is no reason to believe, *a priori*, that it would not apply to man.

Having known this fact for many years, it is interesting to observe that no one has opted to try this method. I conclude that the quality of life is more important to everyone than the quantity of life, and that is an important point.

Another aspect is the apathy that undoubtedly would result even if we did know a way of extending the human lifespan, and in my paper I used poliomyelitis immunization as an example. One probably couldn't think of an easier way to administer a drug than to put a drop of a sweet-tasting solution on the tip of the tongue; yet in spite of this, fully 40 to 50 per cent of preschool-age children in this country are not immunized against polio. The reason is, in my judgment, that we don't see polio cripples hobbling around the streets any more, and consequently the problem doesn't exist in the minds of young people. I would extend this argument to say that if we didn't see anyone aging in our society—say, by virtue of the delivery of some fluid from the Fountain of Youth—people wouldn't take this fluid, simply because there would be no evidence in our society that anyone needed it.

The likelihood is small that we are going to be able to tamper with the biological clock at the genetic level, where undoubtedly the action really is. It is very optimistic to think that anything can be done in the foreseeable future— in the next 25 years, let's say—for

no other reason than that there are so few funds, and fewer than 25 or 30 people in the world really working in this area.

Sacher: Mr. Hayflick made a very important point—that the discussion of social ethics in an aging society can be conducted only in the context of an understanding of the biological nature, not only of aging, but of man. An adequate context cannot be developed in the time we have here, but I would like to make a few remarks from the perspective of the evolution of the human lifespan and human patterns of aging.

Man has an evolutionary history af about 2 million years. Almost the entire 2 million years was a process of what one might call hominization, during which man achieved all his present physical attributes and—although this is more speculative—all but one psychological attribute.

Man is unique in having evolved old age, because the years that have been added to the human life history, as compared to the life of the great apes, are the postreproductive years. This is clearly seen in the fact that menopause, as far as primatologists know, is a distinctively human evolved characteristic.

Why did this come about? It is a complex question that deserves the attention of biologists working in conjunction with anthropologists and social scientists. I would offer an explanation along these lines:

During this period of hominization there was selection for that kind of behaviors that led to the evolution of increased brain size, increased manual dexterity, the development of very complex traditions of hunting, food gathering, and so on. However, the increase in brain size meant a much lower reproductive rate and a necessarily longer period of dependence. I suggest that it is because of these latter characteristics that the human lifespan evolved with what appears to be the addition of old age on the end—in actuality this postreproductive period of life was adaptive for the species because of the long dependency of the young.

Until about 100,000 years ago that was the pattern. What changed then? Until that time learned traditions, and in fact all experience, could essentially be stored only in the individual memory, the human social group was extremely small, and the success of reproduction (a critical factor in all this) depended on the survival of the parents until the long period of dependency was over. Then suddenly language and symbolism emerged, and the increase in a person's usefulness with age began to come to an end, because now traditions could be reduced to speech and communicated in less than a lifetime.

An expansion of investigations in this area of the evolution of the human lifespan would be important in several ways. One way would be to help us to answer one of the ethical questions we have been discussing: "To what *end* should the lifespan be extended?" To answer this we would have to ask what must be restored or replaced in human life to give it a *cumulative* value—value in the ultimate meaning of that term.

What I have said so far may seem very speculative, but there is concrete evidence for it in the life tables of species. If we go back to Mr. Hayflick's question about whether aging existed in nature before man began to develop civilized environments, I would say the answer is yes, but it existed only because it had a function. A species survives in direct relation to the ability of the individual member of the species to develop, reach sexual maturity, and raise its young past the point of dependency. The lengthening of that period of dependency has resulted in a rectangularization of the life table over the course of mammalian evolution. In other words, the human life table is more rectangular than that of the mouse or the horse or any other species in which there is a shorter minimum duration of life necessary for successful reproduction.

The facts can be illustrated like this: Life expectation increased from mouse to man by a factor of 30. This refers to the average survival time. The average survival is dependent on two fundamental parameters. One of these is the *rate of aging*, which can be measured by the rate at which the death rate increases with age. The doubling time of the death rate is 100–200 days for mice, and almost 8 years for man, so the rate of aging decreases from mouse to man by a factor of 15 to 30.

The other parameter measures the initial constitution, what the organism *started* with, and in terms of life tables this is measured by the initial death rate. In the course of evolution of increased life span from mouse to man, in which the rate of aging diminished by a factor of 15 to 30, the initial death rate has decreased by a factor on the order of 1,000. That is, if one looks at the minimum death rates at the preteen age in man, and at the comparable age just before sexual maturity in the mouse, the death rate in man is 1,000-fold lower.

In other words, in the course of the evolution of human lifespan there was a disproportionately strong selection for a decrease in *vulnerablity to disease.* Here we come to a point discussed earlier. If we speak about the reduction of vulnerability by, say, removing one cause of death, such as cancer, indeed we get results which show that life expectation would be increased by only a few years.

However, there is another context in which to examine this fact. Mice also die of cancer. In the lifetime of a typical population of almost any strain of mice except high cancer strains, 10 or 20 or 30-odd percent of

mice in a population will die over their lifetimes of cancer, that is, within a matter of 2 or 3 years.

Human beings die of cancer but at a lower rate—perhaps a 10 percent mortality from cancer in a lifetime, but the lifetime is now 70 years instead of 2. But man has also increased in body size over the mouse by a factor of something like 3,000 (20 grams compared to 70,000 grams). That means that the risk of cancer *per cell* is diminished by a factor which represents the number of cells at risk. Most biologists agree that this is the way one should calculate this risk, because there is almost general agreement that cancer originates in a single aberrant cell, which establishes the whole clone. So the risk of cancer is greatly diminished in man compared to mouse. Compared to the difference in life expectation, which is about 30-fold, the decreased risk of a single cell transforming to cause cancer has to be on the order of 10,000 between mouse and man.

This has meaningful consequences for what we can do in the future. For one thing, a program that is directed toward decreasing these disease vulnerabilities is likely to be feasible, because we know there is a great deal of genetic variation in disease vulnerability between members of a given population. It is not quite true that reducing disease death rates has only a limited benefit for the extension of life. Since the doubling of the death rate is 8 years, every diminution of the disease incidence rate by a factor of two adds 8 healthy years to the span of life. Hence, this program is beneficial as well as feasible.

Curiously, in spite of the huge human populations for which we have demographic information, we know nothing about whether there is any real difference in the rates of aging between human populations. We do know something about this in mice, however, and the data on survival of different mouse strains suggest that any differences in life expectation that exist between populations of the same species are due to differences in disease vulnerability and not to differences in rates of aging. In other words, the rate of aging seems to be much more deeply embedded in a species genotype, and does not have the amount of genetic plasticity that resistance to disease has.

Why does this matter? Because if we were to prolong life by bringing a decrease in the rate of aging alone, the consequence of this would be to produce a shallower life table. And as Mr. Havighurst and I tried to make clear in our paper, this would disproportionately increase the number of person-years at risk for (the last 10 percent, say, of survivors) who have the highest risks of disease and debility.

On the other hand, if one carried out the alternative program of getting access to the kinds of factors that reduce vulnerability to diseases without altering the rate of aging, the consequences would be to push the whole survivorship curve over to the right. The person-years at risk among the last 10 percent would be no greater, but there would be many more person-years of life among the other 90 percent. This means there would be a *decrease* in the prevalence of the disabled in the population, and in the relative costs of debility and medical care.

Biologists frequently say that their goal is to decrease the rate of aging, and they have tried to approach this goal by several chemical therapies—for example, by administering antioxidants or procaine (temperature-lowering and caloric restrictions are separate cases considered below). However, all of the pharmacological methods, although they are used and proposed as anti-aging agents, do not, in fact, reduce the rate of aging. Insofar as they are effective, they reduce the *vulnerability* to disease. In other words, they have the kind of consequence that I said would be more favorable—i.e., deferring the senescent phase rather than stretching it out. However, the researchers are getting a wrong result so far as their original hypothesis is concerned.

Reduction of caloric intake and reduction of body temperature do decrease the rate of aging and thus lengthen life, but they have a curious consequence. What a person can do in his lifetime is governed by the amount of metabolism he is capable of. However, the increased length of life produced either by caloric restriction or by reduction of body temperature (hypothermia) does not give the individual an increased amount of metabolism or increased ability to work with his environment. He doesn't have any more caloric lifetime—he just has more years of life.

To return to the point Mr. Hayflick mentioned, maybe people haven't tried caloric reduction because they have an intuitive idea that it won't give them what they want. They want a full activity of life rather than a mere extension of it. Merely to extend life on those terms would be extremely disadvantageous, because this would mean that with the same number of calories spread over a larger number of years, more of these calories would be expended on maintenance of essential body functions, fewer calories could be expended on useful or meaningful activity, and the whole thing would be socially disastrous.

Havighurst: Before I ask for other comments, I might take a minute to report on a questionnaire study that we are just completing, in which we have asked questions of members of the Gerontological Society who are in the biological and medical fields. We asked about these two methods of increasing life expectancy, namely, the *rate control* method that you just heard about—slowing down the rate of aging, which can be

done presumably by cooling off the body or starving it at the right time or perhaps by the use of some drugs—and the *disease control* method, which is the one that clearly our colleagues here are favoring.

We asked whether they thought the one method or the other was likely to be more effective in the next 25 years, or whether both would be effective. A good many of them said "both."

We also asked what they thought would happen to life expectancy, and we are getting somewhat more positive responses or optimistic responses than we have gotten from these two gentlemen. Thirty-four percent said there would be an increase of life expectancy at age 65 (life expectancy which is now 14 years on the average), an increase of 10 years by the year 2000. Another 34 percent said an increase of 5 years. Twenty percent said an increase of 2 or 3 years. Twelve percent said it would stay the same, and 2 percent said it would decrease.

To some extent maybe these responses were intended to influence the people in Congress to vote more money for this kind of research, but in any case what we have here is a rather positive view of the likelihood of using one or both of these methods in extending life expectancy by a very substantial amount for people after age 65.

Also, we asked this group of biologists how much money they thought should be put into research to accomplish this goal. We gave them several choices, one of which was $500 million a year, which is roughly the amount now being put into cancer research. Another choice was $2 billion, which is about what the Federal Government is now putting into social services for the elderly. Sixty percent said they thought it could be done with $500 million for biogerontological research.

This is a policy issue. The National Institute on Aging is going to be asking for money for one or both of these kinds of research, and the political process is going to be heavily involved in deciding how much money to ask for, as well as what kinds of research to ask for.

Fullarton: This issue of priority setting and the process for priority setting, particularly the assumptions which underlie the process by which we set priorities in biological research, is a critical issue. It comes up in all three of these papers by Goddard, Hayflick, and Sacher.

Policy analysis is both my vocation and my avocation, and in following that pursuit, I have identified three characteristics in the priority-setting process that might be useful for determining how we set priorities for research.

First is the magnitude of the problem. Here, because aging is the one biological condition common to all, research on aging certainly qualifies under this first criterion.

Second is the public's perception of the problem, and by "public" here I mean individual perceptions of the problem, as well as the outcome of political decisionmaking processes in terms of legislation. I will return to this in a moment because it is the most controversial of the criteria.

Third is the scientific opportunity for advance, and here research on aging could certainly qualify as a priority area.

The criterion of the public perception of the problem has two facets. At the individual level of perception, it can be thought of as a kind of horror factor, and I think it is this horror factor that explains the war on cancer. It has been shown that the condition people most fear is cancer, and that fact is responsible for a lot of the political support and for the grass-roots support for the conquest of cancer. (There were also, of course, opportunities for scientific advance with regard to cancer, and the magnitude of the problem is significant.)

We also have a National Eye Institute, not because there are research opportunities for scientific advance, and not because the problem of blindness is a large problem, although of course both these things are true—but because blindness is the thing second to cancer which people fear most. As long as 65 percent of our biomedical research is supported by public funds, what the public is concerned about is a very important criterion.

There is really an exquisite irony that struck me in reviewing these papers, and that is that most people in the field of aging are very concerned about the youth-oriented society, and they decry the youth culture emphasis. But it could well be that from this youth fetish, sufficient horror of the process of aging will arise to provide the kind of public perception of the importance of the problem that will then lead to more research. I think most people here would agree that that would be a great irony.

Broad public support for research on aging, including research on the sigificant extension of life, does not now exist. We have a National Institute on Aging, established through the Research on Aging Act of 1974, not for the reason stated in the preamble, that it is because aging is the one biological condition common to us all, but rather because gerontologists want a larger investment in research that they call gerontology—meaning those activities which are conducted by people who now call themselves gerontologists.

All of this brings me to my basic criticism of the assertions of Hayflick and Goddard, that gerontological research is grossly underfunded. We don't have an analytical base for making a statement of this kind. I am sure Hayflick would admit that research on aging is not only that research done by people calling themselves gerontologists, and that important ideas relative to the fundamental processes of aging do not come only from people who call themselves gerontologists. In one analytic sense all research on organisms, from the first cell division of the fertilized ovum, can be thought of as aging research—that is, the process from the beginning to the end, and the fundamental underpinnings of aging research are such biochemical advances as Mr. Hayflick's own work.

In biomedical science, as in society, everything is connected to everything else, and when people decry the low investment of research it is very important analytically to look at what it is people are talking about. We make gross (if convenient) distinctions at some point, but it is very important not to think of aging research as only those things to be supported by the new National Institute on Aging. Our investment in aging research is much larger than the $25 million estimate, and aging research greatly exceeds Mr. Hayflick's definition of aging done by gerontologists.

With regard to the prolongation of life as the primary goal of aging research, that statement really distorts the public policy problem, in my view, I commend Mr. Sacher for the enlightment that comes from his paper, and for the way he has drawn distinctions between different goals of aging research. I support additional investment in aging research through the National Institute on Aging and through gerontologists, but it is very important that we clarify what our policy objectives are, and that we look at the problem especially in terms of the public's perception of the problem, since that is where the bulk of funds for the support of this research is coming from.

I would like to reemphasize what Mr. Wick and Dr. Engelhardt and others have stated so well, that the quantity of life isn't everything, even as a research goal, and certainly not as the national goal to replace the space program.

Hayflick: I would like to respond to the observation that gerontological research is not necessarily grossly underfunded. I think the error was committed when the NIH was initially established, in categorizing biomedical research into a National Cancer Institute, and a National Institute on Allergy and Infectious Diseases, and so on. One must now live with this categorization and argue that without having the initial wisdom to simply stop at the level of calling the entire enterprise a National Institute of Health, one now must continue the categorization in order to emphasize the research efforts carried out in various areas of biomedical research.

I would be the first to argue that we should have simply a National Institute of Biomedical Research, and let the scientists worry with regard to where the priority issues lie. But you have already committed the original sin, and one must continue, since in the eyes of the public the categorization has now been made, and since the impact of aging on everyone's life is so important.

I have argued in my paper that disease-oriented research should not be the mission of the National Institute on Aging, and in fact I think it is reasonable to expect that it won't be. The other institutes at NIH are concerned with disease-oriented research. Aging is not a disease, and it is a fact that the physiological decrements that occur with age simply allow for one expression of disease to occur at higher rates. But one must separate the two concepts, and this is a critical point.

Goddard: The selection of priorities on a national basis is indeed a critical issue. I would hasten to point out that the public's perception of the problem often has nothing whatsoever to do with the priorities that are selected, or the amounts to which those priorities are then funded, if by "the public" we mean the general public. Rather, the power structure that exists in the biomedical field has a great deal to say about what programs are funded, how much they are funded for, and at times who are the recipients of the funds.

If we do anything as a result of such discussions that are beginning to emerge in other parts of the country as well as here today, we might focus upon the mechanism by which we set priorities for health research, and indeed for health services. We are now talking about $115 billion a year. We have never done any careful analyses of the results of these expenditures, not to the extent that we analyze expenditures in other fields. I am speaking not only about research, but also about health care.

I am struck by Mr. Hayflick's remarks concerning the gains in life expectancy, which from 1900 to 1950 really can be viewed as stemming from changes in the environment. The malaria rate in the United States dropped to zero not because of malaria control or its successor, the National Communicable Disease Center, but because economic development permitted people in the South, where malaria was existent, to move into better houses that had screens on the doors and windows.

Unfortunately we make some very dangerous assumptions, that inputs into the health systems are

going to result in outputs that are roughly equivalent. It has been shown in recent years that we should not be so naive.

With regard to gerontological research, or research on aging, I suggest that as a part of our concern, as I said in my paper, we should examine our national priorities, and we should begin to look at how we spend our research funds.

I think one of the major benefits from funding a large-scale program in aging research will be the spinoff in terms of new knowledge in a whole range of biomedical fields. I would not limit the scope of the National Institute on Aging. I think it is a bad institute, not because of the people who call themselves gerontologists, but simply because it perpetuates a system of categorization in biomedical research that I think we have outgrown. I hope we will be wise enough to see that we need to spend more money on research on the fundamental processes of life. We might get much farther in a much shorter period of time.

One final note: We have to be patient. I am very much discomfited by the current criticism of the cancer program. It has been in existence 3 years, and critics are saying, "You really haven't done anything to reduce cancer; in fact, cancer deaths are somewhat on the increase in certain categories." I think the same thing would hold true should we establish the extension of life as a national goal. It will be a difficult task to extend the lifespan, and I think Mr. Hayflick would be the first to agree that, stated positively, there is no reason why we cannot extend life if we are willing to expend the amount of funds and involve the number of scientists required over the next 25 years. It is a rational national goal, and one that would have many benefits, in addition to what you may perceive as the benefit of making life longer.

Havighurst: Thank you. Now we will take the rest of our time on the ethical side of the issue, and I will call first on Dr. Engelhardt and then Mr. Gustafson.

Engelhardt: First I want to make a few general points. There is an important difference between being old and being aged, which is a great deal of the concern that has been raised here.

That leads to my second point that length of life has an instrumental but no intrinsic value; that is, it is good only if you can do something with it. When speaking of extending the length of life, the issue at once becomes, "To what end?" And again it relates to ways in which one can make the life that is extended of significance to the person whose life it is. So a caveat has to be raised here with respect to what might be taken to be axiomatic goals concerning the extension of life.

The third point is the assertion that the ability to control aging will extend human responsibility in many ways. One will be forced to decide in what ways. This will bring us to sketching out what are reasonable human projects, what are the sorts of human projects that can make extension of life worthwhile. With respect to the polio immunization that is now available, one can say that people who do not have their children immunized are now responsible for their children getting polio, an issue not raised before.

As a fourth general point, this expansion of responsibility is the same one we assumed when we began changing infant mortality rates, and again when birth control programs were instituted to stem the population, just as when malaria control was undertaken. In other words, we have long ago embarked on extending life expectancy and the quality of life.

The final general point in my paper was that any talk of the possibility of immortality is dangerous. It obscures the real human problem of dealing with finite issues, of necessarily finite and mortal means.

I raised four particular issues in my paper. First, I argued that the sense of premature aging, as well as what counts as premature death, depends upon (1) what is generally the case for one's cohort, what is the usual expected age at which one's peers die, and (2) what is the scope of one's life projects. These are, of course, related.

The life projects we had for a much more circumscribed life expectancy will no longer be adequate for a longer life expectancy. So, defining or redefining human projects becomes part of the whole issue of shifting human expectations and human values with respect to life.

Second, research to control aging and to treat aging will, whether we like it or not, turn aging into a disease—for if aging or death occurs at a time when it could have been postponed, it comes to be regarded as a disease. Judgments of what counts as health or disease are obviously related to value judgments about how people live.

Third, I briefly addressed the claims that could be made against those who wish to do research to postpone aging. I contend that those persons who are ill due to socially unjust disadvantages have a primary claim upon the resources of the society, and those resources should be given to them, before going to those who survive to usual cohort age but want their lives extended farther.

Other than for the unjustly disadvantaged, I argue that as long as frequently occurring disease is treated, then to invest money to postpone aging rather than to cure the diseases of the young would be a justifiable

gamble to impose on the particular population concerned—presupposing some other guarantees about democratic participation. Such a choice is not unlike other general choices such as whether to have better highways or to have better art museums.

Finally, I touched very briefly on the issue again that the possibility of extending life accents the responsibility to determine the length of one's life, an issue that arises with such current questions as the "living will," and other decisions regarding the use of technology in prolonging one's life.

Gustafson: Most of the points I would have raised have already been made. I have a question from a somewhat theological point of view and that is the whole question of finitude. To put it in a kind of crude way, I suppose something that has happened in the secularization of Western culture is a growing disbelief in any kind of existence after bodily death. I suspect that this has accentuated an anxiety which everybody probably had before, namely, the anxiety that emerges out of our finitude. If I may make a play on an old Calvinistic belief, it used to be said that the chief end of man is to glorify God forever, or the chief end of man is salvation. In a sense, in the absence of that kind of post-life view, the chief end of man has to be health. The chief end of man has to be the provision of the necessary conditions for full satisfaction of all aspirations that can be reasonably held within a finite lifespan.

I take it that some theologians in the past have said something that is verifiable on a number of grounds other than very private grounds, namely, that to recognize our finitude and to accept its reality is a very, very difficult thing. Surely one of the reasons we undertake many things that are beneficial to ourselves and to others is that we try to overcome finitude to some extent; that is to say, we try to learn more and more, we try to provide conditions which not only extend but enrich life, and so on.

There is also a kind of perverse desire to extend one's life, and I suppose in traditional religious language it is talked about in terms of the problem of idolatry—that is to say, the anxiety that emerges from the recognition of our finitude drives us to find some measure of security to which we can latch on. This in turn can be translated into a strong drive simply to sustain the necessary conditions of survival.

I want to make one other comment, which comes not so much from a religious tradition. The question intrigues me, and I want to address it to George Sacher and Leonard Hayflick: What is the proper group, when we are talking about the benefits of life extension? We talk about the proper social categories when we talk about the distribution of such things as income or health care, but what is the proper group when we talk about benefits of a longer lifespan?

When working with physicians, it is benefits in terms of the individual patient. The covenant between them is to have the physician seek that which is beneficial to the particular patient. In other settings, one also thinks about what is beneficial with reference to certain collectivities, such as families, communities, nations, and so on.

Frequently, when one reads another kind of literature, for example population genetics, one finds the concern is for the human species and its survival.

I want to ask a technical scientific question that I think would make a moral difference: What is likely to be the significance, for whatever one wants to count as benefits to the *species*, for an extension of the human lifespan? I think the question has implications if we think in terms of obligations to future generations.

Hayflick: It is a very interesting question. As a matter of fact, you may be surprised at the answer, because to the best of my knowledge there is no benefit to the species, including the species of man, to have its members survive much beyond the period of maximum ability to procreate. I know of only one exception, which is rather curious. There is a species of moth in which the older members of the community take on the coloration of the younger members, and go through color phase changes. When they do so, they can mimic the movements of the young moths, and therefore attract predators away from younger members of the community.

Unless we can evolve a similar situation in the human species, then I would say that there does not seem to be any benefit to our species to have individuals survive beyond the period of maximum ability to procreate. I think this is the root of the question before us today.

Sacher: My study of population biology leads me to believe that there is a definite adaptive value for man in surviving completion of his immediate reproductive role. Obviously, rearing the young is important, and while the presence of older individuals may not be obviously beneficial in all animal societies, in elephant societies mothers help their daughters and other members of their kin group to bear young. The leader of an elephant herd is typically a postreproductive female. Apparently, in circumstances where there is a long period of dependency and an extremely low reproductive rate, both of them found in elephants and in man, there has been evolution of postreproductive survival.

The problem should not be put in only those terms, however, because if we examine the question in terms

that Mr. Gustafson raised, namely, the problem of finitude, we can see it in another light, and we can see also an urgent need for a dialogue among biogerontologists about what is the nature of aging. There is certainly a widespread view that an organism's life consists of norms, and in some sense perfect function, on which is superimposed a process of aging—so that if we can eliminate aging, then we will achieve indefinite extension of life, physical immortality.

I don't share that belief, an alternative view—that the finitude of life in its temporal duration, i.e., in an *extensive* characteristic, is inseparable from the finitude of intensive performance of vital functions. In other words, the quality of life of the living organism is in some essential way related to its duration. Living longer is necessarily living better.

I would point out that there has been progression of both aspects of life during evolution. Man is the longest lived of all mammals, and his whole life is a qualitatively much richer one. Therefore, if the limitations on man's lifespan are the consequences of his finite precision vital function, then the transcendance of finitude in this intensive sense is the only path to a transcendance of the finite duration of life. That is basically different from the idea that there is something called "aging" which is separable from a perfect existence that we already possess. The research programs that would be involved are also very different because if man's longevity is limited by his finite physiological stability then research on the control of aging should focus on getting down into the fundamental genetic determination of the stability of life systems.

That is not a research program that will give a rapid payoff, and solving the problem in those terms is not going to be easy in the atmosphere of a national program because—you know how it is—you are going to be asked, "What have you accomplished this year?" It is not a research question of that type. We have to develop a disciplinary basis, which requires decades of very basic work, without constant harassment. Mr. Gustafson's question on the ethics of life extension is closely linked to an almost immediate question of policy—what kind of research on aging shall we encourage?

Engelhardt: I want to be briefly meddlesome, Mr. Gustafson, and raise a number of questions before you get an answer to the one you raised.

You asked what is likely to be the species benefit of the increase in life. I want to draw our attention to the question, What do you mean by "benefit"? Almost all the discussion turns on the different ways one could define benefit. More than that, it is not at all clear what is "species." What is a species, that it can be benefited? Is it a continuity of germ plasm? Is it a culture that can be enriched? Some sort of community of rational persons? It is well to attend to the richness of the question.

Gustafson: Yes, we must be aware of the complexity. Mr. Hayflick, since you indicated there are no biological benefits of postreproductive life, are there any predictable disbenefits? Are there harms for the species that might arise from extension of the lifespan?

Hayflick: There are very likely to be disbenefits, and I tried to make that point in my paper and also in what I said earlier—we wouldn't be sitting at this conference if we weren't worried about the problems or the disbenefits.

I think the problems we now face are based on the fact that we have increased life expectation by 20 or 30 years since 1900. Since we haven't dealt with those problems in a spectacularly successful fashion, I doubt that any further increase in life expectation is going to make the problems any less severe, but that they would become even greater. This is the dilemma.

I also would like to respond to Dr. Engelhardt's statement, in trying to break down this question of benefit to the species. This is an important question. We tend to think that increasing our life expectation from a biological standpoint is somehow desirable, because unconsciously we feel really that what we want to extend is our own consciousness. That we do have a mechanism for maintaining the immortality of our germ plasm is obvious to everyone. What we really mean when we speak about immortality is perhaps the selfishness of wanting to continue our own conscious state for a longer period of time.

Fullarton: There was one point in Dr. Engelhardt's paper that I would like to comment on, because it is a very important analytic contribution to the analysis of a social policy issue, and that is his emphasis on life projects. This is opposed to the economic productivity model that characterizes many discussions of policy decisions and their benefits.

Jonsen: May I say something about life projects and life expectancy? It seems interesting that when we talk about extending life expectancy for individuals, we are experiencing at the same time a very rapid acceleration of social and political change and technologies. We might ruminate about the problems of coordination between extended personal life and very rapid technological change. We have been talking about the problem of meaningful life for the elderly. At the same time, if we talk about extending that life, we mean that elderly people will live out a kind of planned obsolescence perhaps several times in the course of their lives,

because meaningful participation would involve familiarity with the changing world and the efficacy of skills and knowledge.

One might reflect on the manner of the ancients, thinking of the finite individuals as being part of an unchanging, eternal society or state. One thinks of Horace talking about having built in his poetry a monument that would last forever. What we might be doing instead is creating an infinite individual who would live through a succession of societies in the course of a lifetime.

Nell: Is there any evidence to suggest that prolonging *lifespan* might lead to a similar sort of result that we have seen in industrial societies in prolonging our life *expectancy* through disease control, which is that women have been affected more favorably than men? Might there be a sex difference in the prolongation of the lifespan?

Sacher: I believe that the sex differences in human life expectation is probably the consequence of natural selection and that it accompanied the differentiation of roles for men and women under the conditions in which the selection occurred namely, in precivilized society. Therefore, I don't see any reason why any specific means of prolonging life would affect the sexes differentially from this point onward.

Havighurst: Do you mean this would tend to equalize longevity between the sexes?

Sacher: It would not necessarily increase the present discrepancy.

Havighurst: How did we get the present discrepancy? Is that built in?

Sacher: I am afraid it is a genetic factor.

Havighurst: It is not environmental?

Sacher: As I said, males and females have different roles, and a logical way of accounting for them is by saying that the burdens of childbirth and an extended period of childrearing on the female were compensated for by a sexual dimorphism with regard to disease resistance and resistance to death—that is by a kind of persistence factor that females have as part of their reproductive adaptation.

Havighurst: Are you talking in biological language?

Sacher: Yes. I relate it to the fact that the human female has evolved the role of having offspring and raising them, in which success requires a long period of persistence. This undoubtedly had some reflection in female physiology.

Havighurst: In general, mammals have this general sex difference?

Sacher: The sex differential in longevity of the human female is only a phenomenon of this century, and before that life expectation for women was *less* than that of men. The same is observed in other species: removal of the stress of breeding prolongs the life of the female and frequently, although not always, it then exceeds the male.

Neugarten: Dr. Goddard, we talked about caloric and temperature reduction, but we have heard little today about the effects of drugs. Can you talk a little about that? Also, in view of the comments Miss Fullarton made with regard to policy, and your own comment about the power structure, would you elaborate a bit about the potential role of drug therapies on prolongation of life, and where the power structure in the policymaking side of government enters into it? For instance, if you had a drug in your hand this morning that could extend the lifespan, what would happen? Would policymakers decide to produce it on a large scale? And encourage people to take it?

Goddard: As a matter of fact, I did take such a drug this morning. I take three of them each morning. It is an interesting drug. It is a well-known compound, and in animals it does prolong life substantially. I have been taking it experimentally for about a year. It is a very fortunate compound, in that it has one side effect: It relieves anxiety. So, even if you die soon, you don't worry about it.

With respect to pharmaceutical agents, I would say that it would be almost serendipitous if we were to discover one that would have the effect of extending life. The reason is because there is so much to be learned with respect to the intracellular phenomena and the interrelationships that occur, that these phenomena must be understood before one can tailor a drug that would have the effect of extending the lifespan.

Alex Comfort makes the point that in fact we may discover a way of extending life before we understand why. Oddly enough, one would think that the Food and Drug Administration might today provide a substantial barrier to testing such an agent, and some people therefore think of the FDA as possibly standing in the way of life extension. But I am concerned in the other direction. I don't think FDA is concerned enough about the requirements for testing.

The one agent I have been taking has been approved for investigative trial in people who are age 75 and over. This tells me that the protective screen is not as tightly drawn as it should be. I would hope before we take that step of human experimentation with life-extending drugs that a great deal more thought is given by a

regulatory agency or any agency that is given the responsibility—in fact, one of my major concerns would be how we would reach a decision, as a society, that such a drug should be developed and marketed. The same would hold true for other types of procedures, whether a drug or something else. We have a lot of moral and ethical issues that we are very familiar with, surrounding other medical procedures, and they might enter here, too.

As far as the power structure is concerned, I listened to the comments about the National Cancer Institute and the National Eye Institute, and the fact that the public fears cancer and blindness. Of course they do. But I have to tell you one thing they fear even more, and that is death. We don't have a National Death Institute or National Life Institute.

Not to be facetious, I think it is going to be extremely difficult to get the kind of public support that would satisfy those persons who are interested in life extension as a national goal—the support needed to develop the training programs, and the basic research programs, the underlying support of the magnitude suggested in my paper. It would be very hard to do, because there isn't a coalition of interests today, such as the Mary Lasker-Lister Hill-John Fogarty actionists who pushed so much of the health program in the early days. That kind of leadership is lacking.

Oriol: I was a little disturbed at the description of the National Institute on Aging that developed here today. It is almost as if the NIA as described here was created to make use of the information it develops to extend life. But I assumed one of the purposes of the NIA is to have greater understanding of the aging process and, once that information is available, to make wise use of it in some other way, not necessarily that the NIA be put in charge of the use of the information it develops.

Bernice Neugarten and others have gone to very great lengths to assure that in the NIA there will be other disciplines represented in addition to biology. Perhaps the problem is that the NIA is in the NIH, and that it is not fighting a disease but attempting to provide information on a number of social as well as biomedical fronts—information which we all need if we are to deal with some of the issues we are discussing here.

Noble: To be provocative, this discussion has gone on about the extension of life, without consideration of the trunication of life. I wonder how the theologians and the biologists would vie- certain policies which would relate to the reduction of suicide among the aged population. There seems to be a trend toward higher incidence of suicide as the cohort ages.

There is also the question of what do you say to the cancer patient who, in intractible pain, cries out for surcease of that pain, for the drug that will put an end to it? It relates to the quality-of-life issue, I am sure, but it also relates to some common, everyday dilemmas.

Engelhardt: I will comment only in part on the points you raise. As you know, at the end of my paper I give a truncated apology for allowing suicide under certain circumstances. I suppose I should remark that up until January 1973 it was not a crime to aid or abet suicide in Texas. Still, remarkably few people took advantage of the loophole, which is to say that if one removes sanctions against aiding and abetting suicide for those people who are in great pain, I don't think one would need to worry about a rush of people to exit. This is a utilitarian answer to those who have developed arguments against allowing people who are in pain to end their lives. I can't imagine what general moralistic argument one would ever give to constrain a person whom one felt fulfilled other criteria for making rational decisions—how would you argue he should be constrained from choosing to end his life?

Wick: I would like to pick up a point Mr. Oriol made about the support of research. It pleases me to know that the Institute on Aging is concerned primarily with understanding what goes on in aging, how it happens, and so on. It does seem to me that we may use our knowledge foolishly, but knowledge itself is never really a bad thing, aside from being one of the chief ornaments of man.

It does seem to me, however, that if we tried to gain support—and I am only saying in another way what I think Dr. Goddard and Mr. Hayflick mentioned earlier—if we try to gain support for this project of understanding the aging process as a great crash program to bring us indefinite life, it will backfire, because it will raise the same old question in the public mind, "What have you done for us this year?" I think also it will be a matter of making clear *why* we are doing it. The question must be answered, "To what end?"

Appendix A
Future Numbers of Older People

Proportions of Older Persons:

At the turn of this century, 4 of every 100 persons living in the United States had reached the age of 65. Now it is 10 of every 100. The proportion may rise, then fall, or it may rise steadily, depending primarily upon future fertility rates.

If the condition of zero population growth were reached and then maintained (a situation that would result from replacement-level fertility, zero net immigration, and slightly declining mortality rates), about 17 percent of the total population would be 65 or over, and about 8 percent would be 75 or over. The stationary condition could be reached about the year 2025 at the earliest.

Table A–1 shows the projected percentage of the population that will be aged 65 and over in future decades. The range of the projection becomes greater at successive points in the future. If fertility rates are high, the proportion of older persons will remain around 10 to 12 percent; but if fertility rates are low, the proportion might climb as high as 20 percent after the year 2030.

Table A–1 Projected Percentage of the U.S. Population Reaching Age 65 and Over

Year	Percentage	(Range)
1980	11.0	10.9 – 11.1
1990	11.7	11.1 – 12.2
2000	11.7	10.7 – 12.5
2010	11.9	10.3 – 13.3
2020	14.6	11.8 – 17.0
2030	17.0	12.8 – 20.9
2040	16.1	11.0 – 21.1
2050	16.1	11.3 – 20.7

Source: U.S. Bureau of the Census. 1976. Demographic Aspects of Aging and the Older Population in the United States. Table 5-1. (*Current Population Reports, Series P-23, No. 59*). Washington, D.C.: U.S. Government Printing Office.

Number of Older Persons:

The number of persons aged 65 and over has gone from 3 million to 22.3 million since the turn of the century, a sevenfold increase. Future numbers of older persons can be predicted with relative accuracy because they are unaffected by future fertility. All the people who will reach 65 by the year 2000 or even 2040 are already alive; and while mortality rates have declined, they have changed slowly, without the wide fluctuations that have been characteristic of fertility rates.

The numbers of older persons are expected to increase substantially over the next 75 years, but at differing rates in successive decades. The Bureau of the Census projects the numbers to go from 22 million in 1975 to over 30 million in 2000; then to jump to nearly 43 million by 2020, as the large number of persons born during the "baby boom" of the late 1940's and 1950's reach old age; then to grow more slowly again and reach 50 million by 2040.[1]

These projections are based on the assumption that mortality rates will decline "slightly" to the year 2000, with no further declines thereafter.

McFarland[2] has calculated other sets of projections, one based on a 1-percent decline per year in age-specific death rates for persons aged 20 and over, with the declines cumulative to the years 2000 and 2020; another based on a 2-percent decline per year.

These various projections are shown in table A-2. They have in common the presumption that declines in mortality will result from a variety of factors: changes in dietary habits and smoking practices, working conditions, atmospheric pollution, the extension of medical

[1]U.S. Bureau of the Census. Demographic Aspects of Aging and the Older Population in the United States. Table 2-1. (*Current Population Reports, Series P-23, No. 59*). Washington, D.C.: U.S. Government Printing Office, 1976.

[2]D.D. McFarland, The aged in the 21st century: A demographic view. Paper to appear in L. F. Jarvik (Ed). *The long tomorrow: Aging into the 21st century*. New York: Gardner Press, 1977.

knowledge through public information campaigns, changes in the organization of medical care, and new diagnostic and treatment procedures. They do not presume any major new biological discoveries or scientific breakthroughs of the types being pursued by biogerontologists that might lead to a dramatic extension of the human lifespan.

Projections Based on Changing Causes of Death

Diseases of the heart, malignant neoplasms (cancer), and cerebrovascular diseases (mainly stroke) are the leading causes of death among persons 65 and over; and taken together, they account for three out of four deaths in this age group. Cause-of-death life tables produced by the National Center for Health Statistics have indicated that, if cardiovascular-renal diseases could be eliminated, the gain in life expectancy at age 65 would be 10 years; if malignancies could be eliminated, the gain would be 2.3 years.[3]

The latter statement is often misinterpreted. Cause-of-death life tables do not provide a useful basis for projections of mortality. They are merely analytical tools, providing guides to where it may be most important to apply medical efforts in extending life expectation. For one thing, heart disease and cancer are not likely to be eliminated in the foreseeable future, although death

Table A–2 Projected Older Population of the United States: 1975, 2000, 2020 (Numbers in Millions)

	1975*	2000			2020	
		1% decrease in ASDR**	U.S. Census*	2% decrease in ASDR**	1% decrease in ASDR**	U.S. Census*
All persons						
55+	42.2	52.2	53.5	57.2	79.3	79.5
65+	22.4	30.9	30.6	35.3	44.4	42.8
75+	8.5	14.8	13.5	18.1	18.8	15.4
85+	1.9		3.2			3.8

*Source: U.S. Bureau of the Census. 1976. Demographic Aspects of Aging and the Older Population in the United States. Table 2-1. (*Current Population Reports, Series P-23, No. 59*). Washington, D.C.: U.S. Government Printing Office.

**Source: McFarland, *op cit.*

Table A–3 Numbers of Persons Reaching Age 65 and Numbers Reaching 75 in the Year 2000 (Numbers in Millions)

	Number aged 65	Number aged 75
If current age- and cause-specific death rates continue	1.681	1.284
If death rates from cancer are reduced by 10 percent	1.692	1.302
If death rates from heart disease are reduced by 10 percent	1.703	1.331
If death rates from cancer are reduced by 100 percent	1.799	1.482
If death rates from heart disease are reduced by 100 percent	1.912	1.834
If both cancer and heart disease are reduced by 100 percent	2.045	2.112

Source: McFarland, *op. cit.*

rates from these causes may be moderately reduced. For another thing, it is often overlooked that a reduction in deaths from one disease implies an increase in deaths from other diseases.

Pursuing the latter point, McFarland has made sets of projections assuming that the age-specific probabilities for dying from a given cause are reduced while those for other causes stay at their current values—if, that is, the lives saved by eliminating heart disease and cancer are redistributed across the remaining causes of death. These projections for the year 2000 are shown in table A-3, where cause-specific death rates are aggregated into three groups: heart disease, cancer, and all other causes.

As McFarland points out, the latter three projections in table A−3, those that assume complete elimination of deaths from heart disease and/or cancer, are highly implausible. The main conclusion from the table is that the more plausible assumptions, of reductions on the order of 10 percent, yield fairly small differences in the predicted numbers of persons surviving at various ages.

Appendix B
Life Expectancy in the United States[1]

Although the natural limit of the human lifespan, presumed to be about 110 years, has probably not changed since ancient times, the average age of death (average life expectancy) has increased dramatically since the turn of the century and an ever-increasing number of persons now live to age 80 or 90. This increase is due to biomedical advances, improved economic status and living conditions, and improved public health measures.

The major factor in increased life expectancy is the marked reduction in deaths in infants and children that followed the conquest of major infectious diseases. In somewhat different words, advances in biomedical science and other social and economic changes have resulted in a redistribution of deaths so that deaths now occur much less frequently in childhood and much more frequently in old age. Of all deaths occurring in the year 1900, for example, 25 percent occurred to persons aged 65+. In 1970, it was 63 percent.

Table B–1 shows how life expectancies have changed in the United States from 1900 to 1974. There has been an enormous gain in life expectancy at birth, a gain of some 23 years; but only a small gain for persons who reach 65, a gain of only some 4 years.

Women not only live longer than men, but the increase in life expectancy since 1900 has been greater for women than for men. The increase for both sexes was dramatic between 1900 and 1955, but has since been diminishing.

While the gains have been greater for nonwhite persons than for white persons, white persons continue to live longer than nonwhites.

Table B–1 Average Life Expectancy in the United States, 1900 to 1974

	1900	1955	1974
For all persons			
At birth	49	69.5	72
At age 65	12	14	16
At age 80	5	7	8
For white persons			
At birth: men	48	67	69
women	51	74	77
At age 65: men	11.5	13	13
women	12	15.5	18
At age 80: men	5	6	6
women	5.5	7	8
For nonwhite persons			
At birth: men	32.5	61	63
women	35	66	71
At age 65: men	10	13	13
women	11	15.5	17
At age 80: men	5	9	8
women	6.5	10	10

Source: U.S. Bureau of the Census. 1976. Demographic Aspects of Aging and the Older Population in the United States. Table 5-1. (*Current Population Reports, Series P-23, No. 59*). Washington, D.C.: U.S. Government Printing Office.

U.S. Census Projections

Future gains in life expectancy will depend directly on progress in reducing death rates. The U.S. Bureau of the Census has taken a number of different approaches to the task of projecting death rates: by extrapolating past mortality trends in terms of age-sex-race-specific death rates; by analyzing the components of death rates in terms of causes of death, factors affecting specific causes, and possibilities of reducing the rates for particular causes; and by carrying out comparative

[1]Figures for life expectancy are calculated on the basis of past death rates. Such "expectancies" are not forecasts of survivorship, for death rates change. For example, life expectancy was about 49 for persons born in 1900. If that expectancy had been borne out, there would now be only a handful of people aged 75+ instead of the 8 million actually alive. Death rates dropped dramatically since 1900; thus average life expectancy rose dramatically. While average life expectancy is not, therefore, a good forecast of survivorship, it is a useful index by which to show the changes in length of life that have occurred over time.

analyses with data from other countries where mortality rates are very low. Among various such studies reported in a recent publication of the Bureau of the Census, one study produced the projections shown here in table B–2.[2] It indicates that little increase in life expectation at birth or at age 65 is anticipated for the period between 1972 and 2000.

The conclusion drawn from the various studies cited was: "In sum, there is no sound reason for expecting major increases in life expectation or any significant extension of the lifespan in the foreseeable future."[3]

[2]U.S. Bureau of the Census, *op. cit.*

[3]U.S. Bureau of the Census, *op. cit.*, p. 43.

Table B–2 Projections of Life Expectancy

	1972	2000	Increase, 1972-2000
At birth			
Male	67.4	69.0	1.6
Female	75.1	76.9	1.8
At age 65			
Male	13.1	13.6	0.5
Female	17.0	18.1	1.1

Source: U.S. Bureau of the Census. 1976. Demographic Aspects of Aging and the Older Population in the United States. Table 5-1, p. 41. (*Current Population Reports, Series P-23, No. 59*). Washington, D.C.: U.S. Government Printing Office.

Appendix C
What Is the Likelihood of Major Life Extension?

The projections shown in the preceding Appendix A and Appendix B are based on the assumption that mortality rates will decline as the result of advances in what we have called "disease control." No projections have been made of the possible gain in life expectancy that might result from the discovery of one or another method of "rate control" of aging.[1] This is because such a discovery itself lies somewhere in the future. Neither the nature of "rate control" nor a possible "treatment" to slow the rate of aging in the human organism can presently be specified.

The prior questions, therefore, are these: What is the likelihood that increased knowledge of the biology of aging and of "rate control" will lead to a major extension of the human lifespan? Does such new knowledge lie in the near or in the distant future?

One method of approaching these questions has been to gather the predictions of experts. Several such studies have been reported, all of them based on the Delphi technique. (This technique is one in which opinions are gathered from a number of expert judges by questionnaire or interview; each judge is then informed of the opinions of the others and is allowed to reconsider his own response. When the opinions have been thus refined one or more times, they are tallied for the degree of consensus among the judges. The method is described in detail by Gordon).[2]

One such study, by Bender, Strack, Ebright and von Haunalter[3] compared the findings from three earlier inquiries:

(1) One was by Helmer and Gordon,[4] sponsored by the RAND corporation, in which a small group of experts were asked for their predictions of "scientific breakthroughs." One of the 31 items was "Chemical control of the aging process, permitting extension of lifespan by 50 years." (While the average number of judges responding to successive forms of the questionnaire was 14.5, neither the actual number of judges responding to the item regarding life extension, nor the qualifications of those judges, was reported.)

(2) A second was based on a panel chosen from the scientific staff of the pharmaceutical firm, Smith, Kline and French Laboratories, in which participants were asked to list needed and feasible breakthroughs and trends in the areas of biomedical research and drug therapy, and to indicate when they thought each event would be implemented or widely accepted. (While the total number of judges was 196, neither the number nor the qualifications of judges responding to items regarding life extension was reported.)

(3) The third, also supported by Smith Kline and French laboratories, used the same approach as before, but with an outside panel of 35 persons who represented the major biomedical disciplines. In this instance, the qualifications of the 35 judges were described in some detail. (The majority were giving substantial effort to teaching, biomedical research, clinical research, or clinical practice; and they rated their own levels of expertise by indicating whether their knowledge was derived from "awareness," "reading," or "working in the area.") Here, again, the number of

[1]The Bureau of the Census has, however, indulged in speculation regarding the most extreme situation and has set forth some projections of growth rates of the older population that would occur if deaths were eliminated altogether—in short, if no one were to die. "The population 65 and over is currently increasing at 2.4 percent annually; with zero death rates the growth rate would jump to 8.3 percent in the first projection year and then gradually fall back to 2.9 percent in 2000, and 2.8 percent in 2025." (U.S. Bureau of the Census, *op. cit.*, p. 44). A life expectancy of infinity taxes the imagination; and we know of no reputable scientist who considers it a serious possibility.

[2]Gordon, T.J. 1968. New approaches to Delphi. In J.R. Bright (Ed.), *Technological forecasting for industry and government.* Englewood Cliffs, N. J.: Prentice Hall, 1968 pp. 134-143.

[3]Bender, A.D., Strack, A.E., Ebright, G.W., and von Haunalter, G., 1969. Delphi study examines developments in medicine. *Futures*, 1969, *4*, 289-303.

[4]Gordon, T.J., and Helmer, O. 1964. *Report on a long-range forecasting study, P-2982.*" Santa Monica: The RAND Corporation, 1964.

judges who responded to items regarding life extension is not reported.

In making their comparisons, Bender, Strack, Ebright, and von Haunalter used items which had appeared in similar (although not identical) form in the three studies. Generalizing from those items, the investigators reported predictions regarding "The ability to control the aging process, permitting significant extension of the lifespan." The predicted date (median date given) for achieving control of the aging process was the year 2023 in the first panel; "beyond the year 2017" in the second, and the year 1993 in the third. The investigators pointed out that, as might be expected, great variation occurs among judges in areas such as this where very little hard data are available on which to base projections.

A more recent study by Boucher, Gordon, and Lamson[5] was aimed at identifying areas in the physical, biological, and social sciences that warrant attempts at the assessment of technologies. It included the item, "Chemical control of the human aging process, adding at least a decade of productive life." Judges were asked to estimate the probability of this occurence by the year 1983. In this instance, a total of 37 judges, all of them with prior interest or experience in technology assessment, responded to this item, but only five were regarded as experts because they were actually working in this area. Of these five persons, one thought the probability of widespread use of chemical control of the human aging process was "virtually certain" to occur by 1983; two thought it "as likely as not;" one thought it "not very likely;" and one thought it "virtually impossible."

While the date queried in this study, 1983, is considerably nearer at hand than the dates given in the preceding three studies—the years 1993, 2017, and 2023—the range of responses indicates the same general lack of consensus, even among persons regarded as expert in the area.

A more elaborate study is now underway by The Futures Group of Glastonbury, Conn. The objectives include the identification and forecasting of life extending technologies in the next 25 years, and the examination of demographic, economic, and societal consequences that might flow from different technological advances. In the first phase of this study a carefully selected panel of 25 biomedical experts was interviewed at length regarding technologies that could affect life expectancy. The panel members are experts in cardiovascular, cerebrovascular, and cancer disease control, tissue regeneration, organ transplantation, cellular aging, whole organism aging, and the effects of the physical environment on health status.

While the findings from this study are not yet published, a preliminary report by Gerjuoy and Gordon[6] summarized the forecasts made by this biomedical panel.

Two classes of technologies were differentiated: those aimed at increasing the maximum lifespan ("span-extending"), and those aimed at increasing the numbers of middle-aged people who live to extended old age, thus adding to average life expectancy ("curve-squaring.")[7] The span-extending technologies are those involving dietary control or supplementation, those that might alter the aging of key organ systems in the body; those that might alter "programed" aging, such as hormone-induced aging; and those that might involve tissue regeneration. The curve-squaring technologies are those relating to the prevention, diagnosis, and treatment of cardiovascular and cerebrovascular disease and cancer, organ transplantation, nonbiological prostheses, improvements in life style (as through public health education) and improvement in the environment.

Pointing out that the span-extending technologies are much less certain than the curve-squaring technologies, Gerjuoy and Gordon report consensus among panel members that the span-extending technologies will not be available until after 1990, and that their effects—if those technologies can be achieved at all—will not be felt demographically until well into the next century.

The curve-squaring technologies, on the other hand, are expected to affect population size and age distribution over the next few decades, and by the year 2025, to increase life expectancy at birth from the present 72 years to 85 years. The consequence might be that the numbers of persons aged 65 and over will increase to 40 million by the year 2000, and to 72 million in the year 2025 (instead of the 31 million and 45 million projected by the Bureau of the Census).

[5]Boucher, W.I., Gordon, T.J., & Lamson, J.E. *Candidates and priorities for technology assessments. Vol 5. A survey of candidate technologies.* 1973. p. 34. National Science Foundation: Office of Exploratory Research and Problem Assessment: Research Applications Directorate. Washington, D.C.: U.S. Government Printing Office, Stock No. 3800-00176

[6]Gerjuoy, H., & Gordon, T.J. "A Technology assessment of life extending technologies." Presented at the RANN/2 Symposium, Washington, D.C., December 1, 1976. THE FUTURES GROUP, Glastonbury, Conn.

[7]See, in this connection, the paper by Havighurst and Sacher in this volume.

Another study by Havighurst, Neugarten, and Sacher is reported here in some detail because it is based on the opinions of a relatively large panel of judges, all of whom are specialists in the field of aging.

In the winter of 1974–75 a questionnaire was directed to American biologists and medical scientists who were Fellows of the Gerontological Society asking their opinions on two issues related to the extension of the human lifespan:

1. The likelihood of increased life expectation for people over 65, gained through one or the other of two kinds of research:

   a. Reduction of mortality due to improved control over specific diseases, especially cardiovascular disease and cancer (Disease Control)
   b. Reduction of mortality due to slowing down of the rate of biological aging of the body (Rate Control)

2. The amount of money that should be spent on research on biological aspects of aging during the next 25 years.

The questionnaire contained the following introductory question:

> Some biologists are drawing a major distinction between: (A) slowing down the aging process in the body ("rate control") and thus increasing average life expectancy by increasing the "natural" lifespan; (B) reducing mortality from specific diseases, especially cancer and cardiovascular disease ("disease control").
>
> In your opinion, is this a useful distinction? (Yes, No)
>
> If you answered "yes," do you think increased life expectancy is more likely to be achieved by method (A) by method (B), or both?

This questionnaire was mailed to all Fellows of the Section on Biological Sciences of the Gerontological Society who resided in the United States or Canada (N = 95); and half of the Fellows of the Section on Clinical Medicine taken alternately from the published list, (N = 68).

Response Rate

Of the 151 questionnaires delivered by the post office to persons on the list, there were 65 responses, or a 43 percent return (12 were not deliverable by the Post Office). The rate of return was much higher from the members of the Section on Biological Sciences than from the Section on Clinical Medicine, 58 percent and 22 percent, respectively. (These are approximate figures, since the questionnaire did not ask the name of the respondent, but did give a space for "comments," and asked if the respondent was willing to be identified. In this connection, 42 respondents gave their names, and 23 did not. The 23 who did not give their names were arbitrarily allocated to the Biological Sciences and Clinical Medicine Sections in the ratio of those who did identify themselves.)

Opinions Concerning Life Expectancy

The Questionnaire contained the question: Do you anticipate that by the year 2000, average life expectancy in the United States for persons who reach age 65 will increase or decrease (categories of response are shown in table C–1).

Responses to this question are shown in table C–1 and are related to the respondent's answer to the question cited earlier: Do you think increased life expectancy is more likely to be achieved by method A (rate control), by method B (disease control), or both A and B?

The consensus was that life expectancy will be increased between 5 and 10 years,[8] and more by method B (disease control) or by a combination of the two methods, than by method A (rate control) alone.

Opinions Concerning Biological Advances

The questionnaire contained the items:

It has been predicted that the essential mechanisms of the biology of aging (factors that govern the *rate* of aging) will be fairly well *understood* by the year 2000. Do you agree? (Strongly agree, think it likely, uncertain, disagree).

To achieve a greatly increased understanding of the biology of aging, what is the approximate investment in research that will be required?

> An amount equal to that presently being spent on cancer research. (approximately $500 million a year) _____

[8]These opinions that life expectancy may increase by 5 to 10 years by the year 2000 should be compared with the statement made by the U.S. Bureau of the Census (quoted on p. 158, Appendix A) that "there is no sound reason for expecting major increases in life expectation in the foreseeable future." The latter statement is based on demographers' analyses of mortality and morbidity data, and thus represents a quite different perspective. It is based also on anticipated changes in disease control (B), without regard for possible rate control (A).

Table C–1 Opinions Concerning Life Expectancy

	Increase likely to be achieved by:			Distinction	Total
	Rate Control (A)	Disease Control (B)	Both A & B	between A & B not useful	
By the year 2000 life expectancy at age 65 will increase by:					
10 years	3	4	10	4	21
5 years	3	10	4	3	20
2-3 years	2	5	3	2	12
stay the same	2	2		2	8
will decrease by:					
2-3 years					
5 years		1			1
Total	10	22	19		62

Table C–2

	Factors governing the rate of aging will be understood by 2000?			
	Agree	Likely	Uncertain	Disagree
Fellows, Bio Sci Section	3	15	7	5
Fellows, Clin Med Section	1	4	4	0
Fellows, Section unidentified	2	8	6	3
Total	6	27	17	8

An amount equal to that presently being spent on federally supported services to the elderly (approximately $2 billion a year) _____
An amount equal to that presently being spent on higher education. (approximately $15 billion a year) _____

Other (explain)

Suppose the mechanisms of the biology of aging WERE understood by the year 2000, do you think the knowledge could be put into practice by that date? (Yes, No). If you answered "No," why not?

Responses to these items are summarized in tables C–2, C–3, and C–4, with the respondents separated according to their respective sections.

There was no consensus that the "essential mechaisms of the biology of aging" are likely to be well understood by the year 2000, although a sizable group of the biological scientists regarded it as likely.

Neither was there consensus that knowledge about the biology of aging can be put into practice by the year 2000. For the group as a whole, opinions were evenly divided on this point. At the same time, of the 18 biological scientists who regarded it as likely or certain that the biology of aging will be understood by the year 2000, 16 believed also that the knowledge will be put into practice by that date.

With regard to the expenditures of funds for research on the biology of aging, it is of interest that the majority of respondents (especially, of the biological scientists) believed that a half-billion dollars per year,

Table C–3

	This knowledge can be put into practice by 2000?		
	Yes	No	Uncertain
Fellows, Bio Sci Section	16	12	2
Fellows, Clin Med Section	6	2	1
Fellows, Section unidentified	9	12	1
Total	31	26	4

Table C–4

	Should spend annually for research on biology of aging				
	Less than 1/2 billion	1/2 billion	2 billion	15 billion	More than 15 billion
Fellows, Bio Sci Section	5	18	5	0	2
Fellows, Clin Med Section	0	5	1	3	0
Fellows, Section unidentified	1	9	6	1	2
Total	6	31	12	4	4

approximately the amount then being spent on cancer research, would be an appropriate amount.[9]

Illustrative Comments from Respondents

Stress on Treatment of Disease

While fundamental research into the biology of aging is necessary for long-term goals of understanding and retarding aging, improvements in health by better nutrition, exercise, and attention to the prevention and treatment of disease and stress will more quickly achieve short-term goals of longevity within our lifetime.

The elucidation of the basic causes of the aging process cannot possibly be foreseen within the next two decades or so. In this interim, emphasis must be placed on the aspect of *preventive medicine*, utilizing our present understanding of life processes, aging and disease, ensuring that our present acquired knowledge is being used to maximal advantage. It is here that measures of established value and information are not being fully employed.

Stress on Rate Control

It is important that the strategy of "rate control" be kept on the "front burner." Competition between the disease-oriented institutes and the Institute on Aging is unavoidable, and we need to face up to this problem rather than attempt to avoid it by the artificial separation of biological and pathological aging. It is also important that biogerontologists understand the implications of a "rate control" strategy.

In my opinion, there has been a regrettable lack of recognition of the fact that the aging process is a field of study which should be pursued, aside from the attack on specific diseases. I believe that this is due in part to a lack of breadth of vision and of acquaintance with the broad world of living things.

[9]It is of interest to compare this figure with Hayflick's estimate that funds spent on cardiovascular disease and cancer research are 100 times as great as the funds spent on research in biogerontology. Another comparison is that in 1976-77 a total of approximately $20 million was being spent for research on aging in the behavioral and social sciences, while the research budget for the new National Institute on Aging was $19 million, most of this probably to be spent in the biological area.

Combination of Both Approaches

I surmise that (knowledge of) whatever maintains the integrity of the cardiovascular nervous system and brain vascular systems would be most helpful. Here I would surmise that long-term nutritional studies preferably with human subjects on a volunteered basis would be very helpful. The study of hereditary longevity in a given human family with thorough laboratory measurements over many years would be extremely pertinent—if it could be achieved.

Another major goal of biological research in aging would be to determine the main effects of a variety of extrinsic factors such as drugs, alcohol, pollution, irradiation and exercise on mortality and longevity of experimental animals and to evaluate some biochemical and morphological variables in human and animal brains as a consequence of advancing age. Clinically, the overall objectives of a research program concerned with environmental factors in aging would be to determine whether the adult capacity of a mammal may be effectively extended by environmental influences enabling the organism to function optimally for a greater portion of its mature and most productive period of its lifespan.

Social Implications and Other Comments

Research on prolongation of lifespan must face the "For what?" aspects—economic, social, and psychological overtones may be more important in the long run than the technological advances which would make it possible.

An understanding of the mechanism of aging is important in its own right. There may be a moral imperative to make life better. I am not convinced that there is a moral imperative to make it longer. In fact, the social consequences of life prolongation could conceivably make the quality of life worse. Since if life prolongation is possible, the methods will be utilized, the problems as well as the benefits should be considered now.

Despite the optimism of the enthusiasts, I doubt the validity of their expectations. It is one thing to prevent polio or to cure cancer. It is another to enter on a life-modification program with long-delayed visible results, especially one which may (and probably will) require long-term rather than isolated manipulations. Our record for control of arteriosclerosis, diabetes, hypertension, etc., is not that good; in fact the long-term use of many modalities has just as often revealed unanticipated late and serious complications.

An enormous amount of information on mechanisms of aging and relationships between aging and disease is available. We know enough to be able to list priorities for (research) work that can provide answers to the major questions. Most current work on the subject is with inappropriate systems, and consists of the generation of data in the absence of significant questions or the testing of useful hypotheses. Large numbers of people have vested interests in keeping the subject diffuse, and I suspect reducing support would narrow the field down to those who are serious about trying to understand aging, and would be beneficial. It would, of course, be essential that those making decisions about funding have extensive knowledge of the field, and be committed to making progress on the most important questions.

My firm conviction is that longer life should emerge only as a consequence of qualitatively better life, as has been the case throughout evolutionary history. It would be folly to interdict some molecular aging process, and thus arrest aging, while leaving man's mental capacities, personality integration, motor skills, and physiological integration unimproved. Man literally made himself in all these respects during the past million-odd years, and increased longevity was a concomitant. If that process does not continue, human history will abort within a few centuries or millenia. Yet all the chemical "quick fix" approaches do shortcut the improvement of man's biological and psychological nature.

Although I firmly believe in the ultimate triumph of man over present day ecological and energy crises, I am concerned that the continued "technological explosion," during the next 25 years, and the many adaptations required, will create great psychosomatic illness and the ravages of cardiovascular disease, e.g., hypertension, "strokes" and myocardial infarction will greatly erode the advances made in other areas *re* reduction of the tempo of the natural aging process. That is, the tempo of modern living will cause accelerated aging or a progeria-like syndrome.

A problem that plagues this situation is that regardless of increases in lifespan neither the individuals (aged) nor the competitive young are prepared to cope with the psychic problems of the aged. The main point is that if life is to be prolonged we should know what goals we are trying to achieve.

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